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ON THE NEED OF ADMINISTRATIVE CHANGES IN THE AMERICAN UNIVERSITY

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IN the first of a series of articles on the higher education in this country, which were published in *The Forum* during the years 1902 and 1903, I designated the true functions of a great university as "chiefly these three: (1) The highest mental and moral culture of its own students; (2) the advancement, by research and discovery, of science, scholarship and philosophy; (3) the diffusion, as from a center of light and influence, of the benefits of a liberal, genial and elevating culture over the whole nation, and even over all mankind." On raising the question whether the universities of the United States had up to that time discharged these functions in a manner commensurate with their opportunity and with the demands made upon them by the size of their faculties and the wealth of their endowments, it seemed evident to me that we were forced to the confession, "They have not." And while no small part of the causes for this confessed failure must be charged to the general public, with its ignorant or mistaken views in respect to the interests, values and ideals of the higher education, no small part of the blame attaches itself to the internal management of these same institutions and involves their presidents, faculties and trustees.

Within the past ten years there has been a growing dissatisfaction with the character and the workings of the system of administration still prevailing in our larger and wealthier collegiate and university institutions. It has been pointed out that, while this system was admirable in its adaptation and praiseworthy in its results as applied a half-century ago to the small denominational college, it is ill-adapted and far from praiseworthy in many of its results, as applied to the

indefinitely more complex and almost totally different conditions of the modern university. Particularly inept in its character and disastrous in its results—so it is claimed—is the relation which the president sustains to the different faculties of a great university, and to its trustees or corporation or other governing board. In too many instances, it is claimed, this relation interferes with the perfect understanding and cordial, intelligent cooperation, which should always be maintained between the faculties and the governing board. There can be no doubt that, among the men who know most about the secret working of the present system of university administration in this country, and who are best competent to pass judgment upon it, the need of *some* change is keenly felt; and if there is as yet too little unanimity of opinion as to what that change should be, there is a fairly uniform agreement that the time for a franker and fuller discussion of the difficult subject has fully come.

Before saying anything in consideration of the problem itself, I wish to define it—at least so far as this attempt is concerned—somewhat more carefully. In the first place it is evident that the scores of small denominational colleges are not to be reckoned in the same class with the larger private and state institutions which have some valid claim to the title "university." A constitution which worked on the whole so well for them in the older days may continue to work almost equally well under more modern conditions. In their case, the fundamental necessities are such that they can not become anything at all—not to say, anything great—without being for a considerable time under the almost unlimited control of one man, with a corps of a half dozen sympathetic colleagues who are subordinates. It must also be borne in mind, when urging the need of greatly modifying if not totally abolishing the office of president in the larger institutions, that the very importance of the personal element in the successful discharge of this office, can be converted into an argument which counts heavily in opposite directions. Certainly, the office of president in any one of these institutions, under the present system of administration, is no sinecure. He who accepts or holds it may not improperly claim sympathetic pity from his friends, and plead with them, if not with the public, to help him answer the question: "Who is sufficient for these things?" The answer would have to be: Few indeed are, by natural gifts or by training; and fewer—far fewer—of those who succeed by the current political methods in getting chosen to the position. And as in so many instances the final event makes evident, it would seem more fitting to regard the music and the ribbons, the pomp and the paraphernalia, of the inauguration ceremonies as consecrating a victim for a free-will sacrifice than as raising a deified monarch to a sort of imperial throne. It is neither becoming nor necessary to the argument to follow the example of a series of articles published not long ago by

one of our most influential newspapers and denounce the great majority of college and university presidents as habitually guilty of falsehood and selfish intrigue. Indeed, such a charge is to be convicted of the untruth of exaggeration. It is quite enough to point out that the accusation itself, accompanied by the fact that it could find admission to a respectable weekly paper and be so largely credited as it undoubtedly was, offers strong reasons for devising some system of governing our universities which shall help to remove the temptation on the part of any of its officers to resort to such means of carrying their measures; and so make the charge intrinsically impossible and absurd. We desire, then, to keep in the background all suspicion of indulging in personalities, favorable or unfavorable to particular persons, while treating freely of the person of the president, its power and relations to the true functions of the university, in the prevailing system of university government.

And now let us consider what are some of the more important objections to the workings of the form of administration almost universally in vogue. These may be all summed up in saying that, in many, if not in the majority of cases, it hinders rather than helps the smoothest working and most valuable results of a university education. At once we must plant ourselves squarely and immovably upon the proposition that all the legitimate work of the true university culminates in its teaching. From this it follows that all the acquisitions of the university are subordinate to the quality and force of its faculties. Such an "institution of learning" may offer fine and even luxurious dormitories, and a cheap and well-served dining-hall for its students; it may give them agreeable and even refining opportunities for social life; it may have expensive appliances and large and splendid fields for athletic sports and culture; but if it has not the sufficient number and right sort of men in its faculties, it fails just where success is most imperatively demanded of it. All these other advantages, *so far as the work of the university is concerned,* are entirely subordinate. All the other officers are the servants of the teachers. Good health is indeed of vital importance; but in securing it, to refrain from dissipation and to take an abundance of open air in unexhausting exercise, is vastly more profitable than the existing extravagances and absurdities of college athletics. Social life is indispensable for the best development of the human individual; but it is not best obtained in the saloons, or clubs, or even in most of the sodalities popular with university students. I repeat: Everything else must be kept subordinate to the efficiency of the teaching, if the university is to discharge satisfactorily its chief functions. But that I am pleading for no narrow conception of these functions, let me refer to the sentences quoted above. It then appears that, not the students alone who are gathered under her walls are the pupils

of the great and good university; her pupils are also the nation and the world.

What now are the principal obstacles which have stood, and are still standing, in the way of the most efficient discharge of their obligations to their pupils, to the nation and to mankind, by the institutions of the higher and professional education in the United States? If we confine our attention—as indeed our theme demands—to those obstacles which arise more strictly within the university circles themselves, we may say: On the part of the students, the chief are the vices of extravagance, lawlessness, superficiality and idleness. All these are, to an extent, difficult to determine, connected with the grosser vices of certain forms of dissipation. The obstacles arising from the existing form of administration, on the part of the trustees, are chiefly due to ignorance, indifference and a species of cowardice which too often takes the fashion of reluctance to oppose the president or the majority of their colleagues on the governing board, or even to inquire too curiously into the motives or the significance of the measures brought before them by their presiding officer. And, finally, the smooth and efficient discharge of the functions of the university are hindred by insufficient education, lack of didactic skill, tactlessness, indifference or low moral tone, in any or all of its several faculties.

It would by no means be fair to charge the deficiencies and vices of the student body to the administration of the university, whatever the exact form of that administration might happen to be. The particular list of vices mentioned above are the national vices. And no amount of painstaking or system of discipline can keep life in the university free from infection by its public environment. It is not at all clear for what proportion of the extravagance, lawlessness, superficiality and indolence of the students the university may justly be held responsible. And, of course, previous to prolonged experience it is difficult to prove that these vices would be minimized or better held in check by a somewhat radically different form of university administration.

Of late years, the presidents who have been wise at the beginning, or who have become wise through experience in the early period of their career, have been more and more inclined to leave most of the discipline of the students in the hands of the faculties, or of the appointees of the faculties, to which the various classes of the students belong. In a large institution, the less there is of the one-man-power discipline, on the whole the better. Especially is the president tempted by favoritism, prejudice, various kinds of fears and by personal or family or friendly sympathies, to act unwisely if any power of punishing or pardoning is left in his hands alone. It is a misfortune for him and for the institution even to seem to have any such power. Too often has the professor, on bringing forward the name of some member of his classes who had failed in his studies or cheated in an examination, been made by the

presiding officer, through the latter's anxiety to save some notable athlete or the scion of some family of wealth or high social standing, himself to appear the delinquent, either in the artifice of detecting cheats or in the art of teaching those that *will* not to learn if they can possibly help it. Even stronger than any of these other motives may be the desire of the individual officer, if he is the nominal head of the entire show, to be popular with the "boys" and with their parents, the alumni and other constituency of the institution. And so long as such a large proportion of these "friends" (?) look leniently upon, if they do not largely indulge themselves in, the practise of these same vices, how can any one lonely man stand against the multitude for firmness and due severity in discipline? But a body of men like the faculties, or their selected committees, in a great institution, is much more likely than any one man can be, to administer even-handed justice, tempered with reasonable mercy. While, then, I am by no means prepared to quote with unlimited assent the following declaration taken from a pamphlet, entitled "The Demoralization of College Life": "College presidents are not willing to enforce the law or even to allow it to be enforced when it will cause them to lose students, especially rich and influential ones." I am fairly confident in the belief that the total elimination of even the appearance of one-man power or influence would greatly improve the *morale* of the student body. And this *morale,* whatever is to be said about it as compared with other countries and earlier days in this country, is certainly quite too low at the present time. It can be raised, and that without any very severe difficulties; and it would, in no very long time, be raised, if the men in the university faculties who sincerely want to see it raised, were given a free hand. Perhaps they might not have the "nerve" at once so to check the extravagance of college athletics as to make it no longer possible to spend a half-million dollars on a single game of bootball; or difficult for the sons of impecunious teachers or country parsons to embarrass their parents by calling for a goodly slice out of their salaries, in order to attend in proper style a dance that rivals in magnificence a state-ball at Government-House in Calcutta.

But is not the present prevailing form of university administration the only one under which the trustees, corporation or otherwise named governing board, can successfully discharge their part of the administrative functions? In these days, universities can not grow in other respects unless they grow in their finances. And there is something appalling, even to the multimillionaire, in the remorseless appetite of the American university for an ever larger expenditure of money. The trustees by advising and assisting the president, and by answering generously to a certain obligation put upon, or gently hinted to them, when they are chosen to the position of trustees, are supposed to be under obligation to oversee the getting and the expenditure of the

required money. But the obstacles which they may, for the most part unwittingly, throw in the way of the efficient work of the faculties of the university are chiefly due to their ignorance of the principles and right methods of education, or to their indifference toward the supreme ends of education, or to their reluctance to criticize—much more oppose—the will of the president or the majority of their own body. Indeed, their position and their action quite too often corresponds to that of the trustees of some bank or other large corporation, who altogether too late wake up to find themselves convicted of conniving at some imprudent or illegal transaction on the part of the official whom they have trusted incontinently.

The vice of extravagance in administration is being distinctly fostered by the system at present prevailing in our larger and wealthier universities. Money is much too largely given to bricks rather than brains, to mortar rather than men. In other words, too large a proportion of gifts and of income is being spent on needlessly expensive buildings; too small a proportion on teachers and explorers of first-rate ability in the several faculties. It is only a partial, but by no means a sufficient, excuse for this vice (?) of extravagance to say that we are now in the brick (stone) and mortar stage of our educational development, and that, when we have provided a splendid and complete equipment of the material sort, *then* we shall be ready to turn our full attention to raising the intellectual and spiritual equipment. For the drift of our experience and the point of the argument for a change lies in the fact that the present system is working toward the degradation of the professorial office and the depreciation of the functions and the *personnel* of the faculties. The fallacy for the other chief argument for this sort of extravagance is less obvious. It is said—and truly—that it is easier to get large sums of money for fine buildings than for great teachers or for stimulating scientific research. In reply, it is not necessary to credit the cynical saying of Europe—although there is much evidence in its favor—that the real scientific work done in the scientific laboratories of the United States is in inverse proportion to their magnificence. Nor could any real friend of the American universities feel otherwise than pleased and grateful to see them equipping themselves with buildings sufficiently commodious for calculable future needs, of good academic architecture, but above all, of the highest serviceableness. But such a friend can not in the same way approve the building of luxurious dormitories, where only the wealthy can really afford to live with any show of an honest independence. The simplicity and severity of the student life, in this and other similar regards, in the public schools and the colleges of the great universities of England are in refreshing and suggestive contrast to the extravagances and class distinctions of republican America. And when, contrary to the good judgment of the teaching force, scores and hundreds of thousands of dollars are unnecessarily

spent merely or largely to glorify the administration as a notable "building era" in the life of the university, it would seem that the foundations of an argument were laid for giving the men who have the work of teaching and research in charge, a much larger share in determining such matters.

These things, however, are of minor importance compared with the way in which the present system works out, too often, in practise, as affecting the very delicate and important but now remote relations between the faculties and their governing board. So long as these relations are chiefly—not to say wholly—through any one man, there are almost sure to be misunderstandings, heartburnings over real or fancied wrongs, jealousies and suspicion of favoritism and of intrigues, even if this one man is equipped with an inconceivable breadth of culture and of variegated scholastic interests, mingled in due proportions with the wisdom of a Solomon, the self-sacrifice of an apostle, and the temper of an angel. A few university presidents have had naturally, or have acquired, enough of this adorable mixture to pass courageously and patiently through years in so trying a position, and at the last to emerge with a large measure of respect and some measure of affection from their colleagues in the different faculties. But there are not a few other cases where great and irreparable injustice has been done to individuals and no small mischief to the university through lack of an appointed means of securing trustworthy communication between the governing board and the faculties under their control, irrespective of the representations and the control of the president. If the inside history of the mistakes made and the wrongs committed in this way were fully written—and it is probably not desirable that it should be and quite certain that it never will be written—it would be spotted with scandals of the most astonishing character. For example, several years ago a distinguished professor in one of our larger universities, who had given the greater part of his life to its devoted and efficient service, was as a part of the business of a single meeting of the trustees dismissed without further trial from his place; and after the action was taken and inquiry was made as to its grounds, not one of the trustees could be found who was willing to assume any responsibility or to state the grounds on which the action had been taken; or indeed, whether the letter written by the president to the professor fairly and truthfully represented the intention of the trustees. Subsequently, a number explicitly, and all implicitly, admitted that they had been deceived by the president.

From the point of view which regards its morally deteriorating influence on the faculties, the present arrangement is equally unsatisfactory. The men of standing in the world of science and scholarship, and of a high sense of honor, will not willingly resort to the trustees, either as individuals or as a body, unless they are officially authorized or requested

to do so. Of all men, too, they are least likely to run to the president with either complaints or defences, or to take any measures to "make themselves solid" with him. If they are being undermined or traduced by any one, whether on the outside or among their younger and more ambitious and place-seeking colleagues, they are even unlikely to know anything about it, so busy are they in their own work; or if they do know about it, they are not unlikely to scorn to pay any attention to it. But if no action touching the professional standing of any member of the faculties could be taken on the initiative or recommendation of the president alone, there is little doubt that this kind of maladministration would occur much more infrequently.

Indeed, it would seem as though this one contention did not require prolonged or subtle argumentation. Granted even that "the cotton-mill policy" is suitable for the administration of a great university: yet the head of this form of industrial enterprise ought to be, as a "boss," no lest strictly limited than the bosses in other no more important or intricate industrial enterprises. This is the one thing that the labor unions are most vigorously and most righteously insisting upon—namely, that there shall be some adequate and trustworthy means of employers and employees coming near, in a frank and friendly way, to each other.

But of all the objections to the continuance without change of the present system of administration in the great universities, the most weighty and imperative is this: it is one of the most productive of the several causes which are working together to bring about "the degradation of the professorial office." That this process of degradation is really going on, I ventured to assert in one of the series of articles to which reference has just been made. The response which the assertion called forth at the time went a long way toward confirming the opinion. Careful inquiry into the history of the last decade of collegiate and university movements would, I am sure, show that the process has in the meantime not been checked. It is the rather to be feared that it has gone forward with a quickened pace. The causes of this process do indeed chiefly lie beyond and below the power of any form of management largely to control.

Let us briefly consider the case of the young man who decides to devote his life to a university career. The more intelligent and deliberate the decision is, the later it is likely to have come in the course of his secondary education. But under the working of the system of almost unlimited electives which has prevailed in our higher institutions of learning during the past half-generation or more, the candidate for a future professorship is almost certain to discover that he has neglected to lay the foundations of any particular subject solidly and thoroughly well. He knows no *elements,* as the elements of every species of science and scholarship must be known, in order to proceed

safely and with joy in hard work to its ever higher stages of study, research and discovery. But our intending professor can not go back into the fitting-school or into freshman year, and begin over again. He enters the graduate department. Here he has, with few exceptions, as colleagues in study, men who, like himself, are not well-grounded and who are unable or unwilling to submit to the prolonged and severe discipline which is necessary for the training of the intellectual athlete. He is prematurely set at "a problem" and works with an aspiring eye on the degree of Ph.D. That this description is not true alone of the few advanced students trained by the secondary educational system of this country, who are without serious purpose, I may cite the unanimous testimony of the professors and other officers at Oxford respecting the Rhodes scholars in general, as it was given to me on occasion of a recent visit there. They are, for the most part, fine, manly fellows, earnest in work and anxious to pick up whatever might seem fit for their advantage, but superficial in their attainments, eager to *specialize* minutely while as yet they know little or nothing thoroughly as to elementary matters in their chosen specialty, and restive under all manner of control, whether as touching manners, petty morals, the prompt keeping of appointments, or conformity to university regulations.

Now that our candidate is ready for his professorial career, how shall he get into a place which will at least give him a foot-hold for beginning a life-long race? He must be, as a rule, recommended by somebody (often some president) to some president, who will, if he thinks best, recommend him to the appointing board. This latter recommendation is usually equivalent to an appointment, although of late the sane custom of consulting some members of the faculty into which the candidate is to be introduced has begun to prevail. In popular parlance, he must push and be pushed. But every one who has had the long experience of the writer in such matters knows perfectly well that the willingness and skill to push one's self, and the vigor and success with which one is pushed by others, are quite as often in inverse as in direct proportion to the merits of one's case.

When all the preliminary stages are passed through, and the candidate has really the right to call himself professor—although the young ladies whom he used to meet at the summer resorts were wont to call him "professor" when he was in fact only a tutor or an instructor—unless he has a most self-sacrificing intellectual interest in his calling and a thoroughly ethical love for the work of the teacher, he finds that his position and its rewards are not at all what he fondly imagined they would be. His classmates who have gone into business or into the professions of law or medicine are in receipt of incomes two-fold or four-fold his own. They have a higher social standing; and those they have served with no higher degree of talents or of success are seemingly more grateful and ready in some form or other to show appreciation of the

services rendered in their behalf. But let him never mind. Perhaps, if he is a true man he does really not much mind. But what he can scarcely help minding is this: His whole career, and the reputation and influence which he has won by a life of self-sacrificing labor, may at any moment be in peril through the caprice, or cowardice, or ill-will of a single man, or of a little group of men who have influence with that single man. Then he will have the choice between a silent submission or an ignoble contest with a probably inglorious—albeit triumphant—ending.

This last and worst of all the many influences tending toward the degradation of the professorial office is definitely connected with the present system of university administration. One can not wonder, and one can scarcely blame, the younger generation if they neither have nor profess the same unstinted devotion for an institution as that which sustained their forebears during lives of self-denial, hard work and low living. They are in it for what they can get out of it, much more than their old-time predecessors were. They need not be at all so careful as their elders were about any shadow being cast upon their reputation for the most upright and austere morality; but they are almost sure to be more careful about standing in with the power that has most to do with appointments and promotions. For the question may at any time be thrust upon them: Which shall I sacrifice, my hard-won position or my highly prized spirit of manly independence?

Immediately following the consideration of the evils of the present system of university administration in this country comes the question: Can these evils be abolished or lessened by any feasible changes in this system? And on the heels of this question follows another: If changes are to be made, what shall those changes be? In treating these questions it scarcely needs to be said that, as a matter of course, no system of administration, to whatever purpose that system may be applied, can avoid encountering and in all probability collecting about itself, a host of embarrassments and of obstacles to its perfect working. Institutions that have developed as large and old universities have, even in this comparatively new country, in fact developed, can not be subjected to radical changes, suddenly, and on grounds of theoretical significance alone. But as I have already said, so obvious and important in their power to defeat the smooth and successful working of the highest functions of a great and good university have some of these evils grown to be, that the time has fully arrived for a frank and thorough discussion of the topics suggested by them. And this discussion may be entered upon with the conviction that some of these evils, and those not the least of them, are so largely due to the nature of a worn-out system, that by changing the system we shall lessen if we do not wholly extirpate them.

In order to point the direction in which changes are both needed and promising, as respects the present system of university administration

in this country, it seems to me that some fixed places of standing may be established. In closing this article I will mention the following as among the most important and perhaps they may be summed up in a tentative way, in this sentence: The administration of a large university requires for its most effective conduct two boards or bodies of men, which have largely different functions and for the most part a different *personnel,* but which are bound to cooperation for the welfare of the university by regularly appointed and trustworthy means of understanding each other's views, necessities, and measures enacted, and by a system of checks that shall operate in guarded ways to make each responsible for its initiative to the other.

Of these two boards which are necessary for the efficient administration of a large university, one should be chiefly responsible for its material affairs. For this reason it should be largely composed of men of sound business principles and experience; but also, as far as possible, of men possessed of a worthy knowledge of the needs and methods of a modern university education and with devotion to high educational ideals. There would seem to be no valid objection to, but much valid reason in favor of, having a small minority of this board chosen from the different faculties of the university. Why should not a professor of business law, a professor of economics, and a professor of architecture or engineering, be useful members of such an administrative body? Even a professor of ethics, if one could be found who combined a firm grasp on moral ideals with a fair amount of practical wisdom, might sometimes serve as a valuable control in the performance of the legitimate functions of the trustees of an institution of the higher education.

It is unnecessary to emphasize the fact that the business administration of a large educational corporation requires the same trained staff of competent and responsible assistants—treasurer, cashier, clerks, etc.—which are required by any other business corporation of equal magnitude; and these paid assistants should be held to as strict account in every respect as that which prevails in the best organized business corporations. If, besides the gifts which are solicited or directed to the endowment or income of a well-organized and well-administered university through the free-will devotion of its trustees, faculties, alumni and other friends, there is pressing need for yet more, it would always be within the province of this board to call to its help especially selected agents for meeting such need. But however the details of collecting and distributing the material resources of the university are managed, and whatever the success which attends their management, it should never be lost out of mind that all their value consists in the efficiency with which they minister to the real ends and promote the realization of the true ideals of a great and good university. These are not in any way necessarily connected with the glorification of any one man or of any

single administration as a money-getter or a builder of magnificent buildings.

The other arm of administration, which ought to be equally strong and self-respecting and independent within its own appropriate sphere, must be wielded by the faculties. But not by them as acting all together, or as all acting equally in any one faculty, or as acting in an unorganized and unrestricted way. The same process which has tended toward the degradation of the professorial office has increased the danger of something resembling mob rule, if every teacher stands on equal terms with every other, in a great university. Yet, in general, the educational policy, matters touching the curriculum, and all the discipline of the student body, as almost a matter of divine right, whether or not by custom or by statute, belong to the men whose craft and experience is in lines of education. And while they should always be thoughtfully considerate of the judgment of their employers, and are quite of necessity dependent upon them in the matter of their salaries and of the equipment allowed for the prosecution of the work of their departments, they should be so related to these employers as to be delivered from all feelings of fear, or wish or chance to curry favor, in the discharge of their functions as teachers and explorers of truth.

In saying this I am far indeed from advocating an unrestricted license for the individual teacher, or even for the whole of the teaching force. The management of the more strictly educational affairs of each one of the separate faculties would, in general, best be left to each one of these faculties. And, indeed, so far as the professional schools of law and medicine are concerned, this course is customarily adopted. In the faculties of these schools there is customarily a moiety of strong and independent men, who can readily take care of themselves if obliged to leave their positions; and while ready to hear and heed advice (or, at least, they ought to be so), they are not ready to take orders unquestioningly from the president or from the corporation. But the same thing ought to be true of all the faculties. When, however, these faculties are large and largely composed of young and inexperienced men, as is sure to be the case with the faculties of the undergraduate schools of a great university, their internal control can not be safely committed to the entire body—share and share alike, as it were. It can not be democratic; it must be aristocratic. And this arictocracy would have—so it would seem—to be selected by joint action of the full professors and the trustees. The method of its fixing might be adapted to the circumstances and the needs of the particular institution. Once fixed, the advice and cooperation of the entire body of officers, of every sort and grade, might be invited or commanded, but the final control of educational matters would rest in the authority of this aristocracy, with the aid of those to whom they might see fit to delegate any portion of it. And, finally, for matters affecting immediately the scholastic interests

of the whole university, and for adjusting differences and conflicts touching educational interests between the different departments, a university council is a most feasible expedient. Only be it understood that such a council should be no sinecure, or body designed to assume a show of responsibility while actually having little power to check intrigues, to judge intelligently and righteously, and to act with something more than a mere shadow of influence or authority.

Most important of all the improvements for which we might have a fair measure of hope, if something like the suggested changes could be inaugurated and fairly and thoroughly tested in the administration of our greater and older universities, would be the improvement in a good understanding and in reciprocal confidence and in effective cooperation, between the board of teachers and the board of business management, between the professors and the trustees. In the lack of knowledge, of confidence and of cooperation, most of the embarrassments, difficulties, failures, and scandals connected with the present system of university administration in this country undoubtedly arise. And perhaps in the majority of these cases they arise from or center about the action of the president. It will be noticed that the scheme tentatively proposed in this article does not *necessarily* call for any president. And, indeed, we may boldly ask ourselves, Why should there be any president, if by this title we mean to cover the office of any one man combining within himself, *even apparently,* all the functions belonging to this name in the days—and, if you please, even now—of the small denominational college? A figure-head to represent the university at home or abroad on occasions of peculiar import and corresponding grandeur can easily be appointed, either with a three-years' tenure or for each special occasion.

Doubtless many difficult problems will arise and await a speedy or more remote solution, in the way of any institution which attempts to inaugurate the needed changes. Doubtless, too, the particular character of the changes enacted would wisely vary in different cases. In the cases of universities under state control, every thing could scarcely be arranged in the same way as in the cases of the private institutions. Doubtless, again, the effect of change upon the alumni and the public at large would have to be seriously taken into the account. But neither the public, nor the alumni, nor the trustees, and perhaps not even the presidents of these institutions, realize how deep is the dissatisfaction with the existing system, how urgent, if not loud, is the call for a somewhat radical change. At any rate, it is high time that the problems afforded by this system should be frankly and boldly faced; high time that the disadvantages should be announced, if not at once corrected.

SCIENCE IN THE SERVICE OF HIGHWAY CONSTRUCTION

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NEW YORK CITY

IN a popular sense, a road is a means of communication by vehicle between different localities. To the citizen who ordinarily uses it, aside from considerations of its aspect and surroundings, the condition of the surface and the ease of traction over it have been the main considerations. He has given little thought to the manner in which it has been constructed and has been, usually, quite indifferent to or ignorant of its cost originally or of that for its maintenance. As the use of the automobile has become so general there has recently been a very decided change in this respect. The movement for good roads has arisen and a general interest in the subject has developed. In what follows an attempt will be made, for the benefit of the general reader, to outline the development of the modern methods of highway construction, and to show how science has aided therein.

The art of highway engineering, that is to say, of the construction of roads, was considered to have been developed to a high degree of perfection at the end of the last century, as evidenced by the magnificent system of broken-stone roads which were in existence at that time in France, more especially, and in England and other foreign countries, while in the United States successful systems of broken-stone roads had been begun in New Jersey, Massachusetts, Connecticut and a few other eastern states. Roads of this type, when constructed by engineers of experience, with suitable stone, of a proper thickness and with a sufficient foundation, properly drained, and when continuously maintained, were found to be adequate to support the severest kind of travel to which they were subjected at that time, at a cost which was not an excessive burden on the state or the taxpayer. The traffic consisted almost entirely of horse-drawn vehicles and the road surface was resistant to a degree which would carry this traffic without rapid deterioration. Roads of this character were known as water-bound macadam, a name derived from their resemblance to the broken stone roads constructed in England by the celebrated highway engineer John Loudon Macadam in the early part of the last century. Briefly, water-bound broken-stone roads, of the highest type known in the United States, and the only form built until recently to carry heavy travel, are constructed as follows:

The grades of the road are carefully studied and laid out in the most favorable manner by an engineer so as to make it as level and straight as possible with due regard to the economics of the problem. Corresponding to these grades the subsoil foundation or subgrade of the road is constructed either by cuts or fills, so that its surface is at a depth below the surface of the road as it is to be finished corresponding to the thickness of the compressed material to be built up thereon. The subgrade must be so prepared, especially in fills, by the use of proper material and thorough rolling with a steam roller, that it is absolutely stable and rigid, and will not be thrown out of shape by frost. The preparation of the subgrade is one of the most important points in good road construction and, although it is purely a structural problem, it is too often neglected or passed over without sufficient consideration and care. It can be readily understood that the rigidity and wearing character of a road can be no greater than that of the subgrade which supports its surface.

Upon the subgrade the road itself is built, or a further foundation may be constructed upon it, if the conditions seem to demand it, that is to say, there are two types of broken-stone roads, one commonly called a macadam and the other a telford road. In the former the broken stone is placed directly on the subgrade and in the latter, from considerations of the character of the subsoil or of that of the traffic on the road, on a further foundation constructed, as described by Mr. Austin B. Fletcher, as follows:

> A satisfactory telford foundation may be made by placing vertically on a layer of gravel, 2 or more inches in depth, stones of fairly uniform size, not exceeding 10 inches in width, 6 inches in depth, and varying in length from 6 to 20 inches. The stones should be set on their broadest edges, lengthwise across the road, and wedged rigidly into position by smaller stones driven by mauls into the interstices between the telford stones. The projecting points should be broken off with stone hammers, the depressions filled with chips, and the telford rolled with a steam roller until it is true to the desired cross section.

The foundation, whether of the macadam or telford type, should be properly drained, since the presence of water softens the subsoil so that the broken stone is forced into it under pressure, weakening the road and destroying the shape of the surface. This provision is very generally neglected in the United States. In addition ditches or channels must be provided on each side of the road to remove the ground water collected by the drainage system and to take care of the surface water which is thrown off the road by the crown, or camber, and the grades.

Upon the subsoil or telford foundation is placed broken stone between shoulders of soil or other suitable material, to prevent its lateral displacement. According to Macadam the stone consisted of pieces of uniform size, about two inches in diameter spread to a depth of ten inches and then compacted by the traffic which passed over the

road. To-day quite a different procedure is employed. The stone is applied in two courses and in two sizes. The first or lower course consists of larger stone than that used for the surface, from an inch and a half to two and a half inches in diameter. It is carefully and uniformly spread to such a thickness that it has, when compacted, a thickness of from three to five inches, depending on the character of the foundation and that of the traffic which the road is to carry. The second or upper course, which forms the surface or crust of the road, is composed of finer stone, one half to one and a half inches in diameter, to a thickness of at least three inches when compacted. Great advances in highway construction have taken place since Macadam's day, in that steam rollers have been available for some decades for compressing and putting in place in a proper manner, the broken stone after it is applied to the foundation. Each course is rolled separately until it ceases to move under the roller.

After the compression is completed a binder or filler of much finer stone is spread over the surface, all of it passing an opening three eighths of an inch in diameter and a considerable portion being fine dust, for the purpose of filling the voids in the upper course of stone, closing up the surface and preventing infiltration of water through it. This is accomplished by the use of water, applied with a watering cart, which washes the fine material into the interstices in the stone. The road is then again rolled with the steam roller, to aid in forcing the filler into the surface, and to render it compact and waterproof. Skill is required in the manipulation of the roller to produce a surface of proper conformation and uniform density.

The method of constructing a water-bound broken-stone road, which has been described in a very general way, is still in use for work of this type, and was the only one employed up to the beginning of the present century, in building roads to meet the most trying conditions then existing. It was a very satisfactory form of construction and still is, under certain conditions and environment. The execution of such work was an art involving great skill and experience, but science contributed but little to perfecting it and placing it on a rational foundation, with the exception of methods of examining the character and availability, from this point of view, of the various rocks which are used in building roads, which were developed in France, and on a much more elaborate scale by the Massachusetts Highway Commission, and in the Office of Public Roads of the United States Department of Agriculture by Mr. Logan Waller Page, the present director of that office, who, with his assistants, has contributed largely to the application of science to the improvement of highway construction. These methods are of so much interest that they are worthy of description.

In determining the suitability of a rock for the construction of a

water-bound broken-stone road, its physical characteristics and its behavior under certain conditions are important. Before the development of means of determining these characteristics in the laboratory, the only way in which they could be arrived at was from observation of the behavior of the particular rock in a road when exposed to travel for a considerable period of time.

The important characteristics of a rock which enables one to judge of its suitability for road construction are (1) its resistance to wear or abrasion by impact, (2) its hardness or resistance to the displacement of its particles by friction, (3) toughness or resistance to fracture by impact, (4) the cementing properties or value of the rock powder or dust produced by attrition, when moistened, (5) porosity or capacity for absorbing moisture, the latter being closely associated, for the same kind of rock, with the specific gravity, and (6) the structure or size of the grain of the rock, the character of the minerals of which it is composed, and the extent to which these may have become altered by weathering, upon which all the other characteristics of the rock will depend.

The methods of determining these characteristics have been largely originated and developed in the Office of Public Roads in Washington, and are described in one of its bulletins, No. 31, as follows:

Percentage of wear represents the amount of material under 0.16 cm. in diameter lost by abrasion from a weighed quantity of rock fragments of definite size. It is determined in the following manner: The rock sample is broken into pieces that will pass through a 2.4-inch ring but not through a 1.2-inch ring, and after being thoroughly cleansed, dried and cooled, 5 kg. are weighted and placed in a cast-iron cylinder (34 cm. deep by 20 cm. in diameter) closed at one end and having a tight-fitting iron cover at the other. This cylinder is one of four attached to a shaft so that the axis of each is inclined at an angle of 30° with that of the shaft. These cylinders are revolved for five hours at the rate of 2,000 revolutions per hour, during which the stone fragments are thrown from one end of the cylinder to the other twice in each revolution. At the end of five hours the machine is stopped, the cylinders opened, and their contents poured into a basin, in which every stone is carefully washed to remove any adherent detritus. This abraded material is then thoroughly dried, and from the amount lost below 0.16 cm. the per cent. of wear is estimated.

Hardness is the resistance which a material offers to the displacement of its particles by friction, and varies inversely as the loss in weight by grinding with a standard abrasive agent. The test is made in the following manner: The test piece in the form of a cylinder about 3 inches in length by 1 inch in diameter is prepared by an annular core drill and placed in the grinding machine in such a manner that the base of the cylinder rests on the upper surface of a circular grinding disk of cast iron, which is rotated in a horizontal plane by a crank movement. The specimen is weighted so as to exert a pressure of 250 grams per square centimeter against the disk, which is fed from a funnel with sand of about 1½ mm. in diameter. After 1,000 revolutions the loss in weight of the sample is determined and the coefficient of wear obtained by deducting one third of this loss from 20.

Toughness as here understood is the power possessed by a material to resist fracture by impact. The test piece is a cylindrical rock core similar to that used in determining hardness, and the test is made with an impact machine constructed on the principle of a pile driver. The blow is delivered by a hammer weighing 2 kg. which is raised by a sprocket chain and released automatically by a concentric electro-magnet. The test consists of 1 cm. fall of the hammer for the first blow and an increased fall of 1 cm. for each succeeding blow until failure of the test piece occurs. The number of blows required to cause this failure represents the toughness.

The cementing value, or binding power of a road material, is the property possessed by a rock dust to act as a cement on the coarser fragments comprising crushed stone or gravel roads. This property is a very important one, and is determined approximately as follows:

One kg. of the rock to be tested is broken sufficiently small to pass through a 6 mm. but not a 1 mm. screen. It is then moistened with a sufficient amount of water and placed in an iron ball mill containing two chilled iron balls weighing 25 pounds each and revolved at the rate of 2,000 revolutions per hour for two hours and a half, or until all the material has been reduced to a thick dough, the particles of which are not above 0.5 mm. in diameter. About 25 grams of this dough is then placed in a cylindrical metal die, 25 mm. in diameter, and by means of a specially designed hydraulic press, known as a briquette machine, is subjected to momentary pressure of 100 kg. per square centimeter. Five of the resultant briquettes, measuring exactly 25 mm. in height, are taken out and allowed to dry for 12 hours in air and 12 hours in a hot oven at 100° C. After cooling in a desiccator they are tested by impact in a machine especially constructed for the purpose. This machine is somewhat similar to that used in determining the hardness, and the blow is about the same, excepting that it is given by a 1 kg. hammer and the distance of drop does not exceed 10 cm.

The standard fall of the hammer for a test is 1 cm. and the average number of blows required to destroy the bond of cementation in the five briquettes determines the cementing value.

The specific gravity is the weight of the material compared with that of an equal volume of water, and is obtained by dividing the weight in air of a rock fragment by the difference of its weight in air and water. Given the specific gravity, the weight per cubic foot of a rock is found by multiplying this value by 62.5 pounds, the weight of a cubic foot of water.

The examination of a rock for structure, its mineral components and the degree to which it has become weathered, is carried out by preparing a thin section of such thickness as to be transparent under the microscope. Its characteristics are then readily determined by the methods employed by the petrographer for this purpose. The appearance of such a section, made from a trap rock of a kind used in the construction of a broken-stone road, is shown in an accompanying illustration, taken from the Bulletin of the Office of Public Roads, which has been referred to.

The application of the methods which have been described to the study of rocks for the purpose of determining their suitability and relative merit for road construction was the first contribution to and application of scientific methods to the subject. Before this road con-

struction was merely an art, more or less skillfully carried on, based on experience, but purely rule of thumb in its execution and not founded on any rational principles. With the application of scientific methods as a means of determining the character of the stone to be selected the building of a water-bound broken-stone road was placed upon a much more satisfactory and rational basis. Roads of this type, so constructed, especially in Massachusetts and under the supervision of the Office of

FIG. 1. DIABASE (TRAP).

Public Roads in other states, were, and are to-day, entirely suitable and satisfactory for carrying horse-drawn traffic. When, however, self-propelled or motor vehicles became an important part of the traffic which these sufaces have to sustain, the latter have been found to be entirely unsuitable for the purpose.

The automobile has introduced an entirely new element into the road problem, and one which can only be solved by the application of the scientific methods. It is in this direction that science has proved itself of the greatest service to the highway engineer.

The destruction of the surface of a water-bound broken-stone road by motor traffic is due, according to experiments conducted by the Office of Public Roads, to the shearing or grinding action of the tires of the rear wheels of cars, which under the impulse of the engine, revolve at a slightly higher rate than that corresponding to the movement necessary to conform to that of the car over the road. It thus acts like a grindstone and loosens up the fine material which is necessary to cement

the surface. This fine material in its loosened condition is picked up by the current of air produced by the rapid motion of the car and is blown away, forming the clouds of dust which is one of the most unpleasant features of the use of motor cars. Of course the greater the speed the greater the shearing action of the tires, the greater the amount of dust loosened and the greater the destruction of the road. As a matter of fact there is little or no damage done at speeds of less than thirty miles an hour. That the damage is due to the rear wheels alone is shown in instantaneous photographs of a car moving at ninety miles an hour over a water-bound surface. Practically no dust is to be seen about the front wheels while a cloud arises from the rear tires. If the commonly accepted theory that the destruction of the road surface is due to the suction of the rubber tires, there should be an equal amount of dust stirred up by both the rear and front wheels.

The present condition of affairs is still further illustrated by the statement of the Massachusetts Highway Commission in its 18th annual report for the fiscal year ending November 30, 1910, which follows:

> The fact that a macadam road will not withstand such travel (motor vehicles) was again demonstrated upon the piece of road that was built in Becket in 1909, around Jacob's Ladder, so called, where the commission constructed a long stretch of macadam road, using the best local stone available. The road was not open to travel until late in the fall of 1909, but before the first of July, 1910, the surface of the road had been torn up in many places by automobiles, and on the corners and curves deep ruts had formed. Consequently, when the road was less than a year old the commission was obliged to spend over $1,400 a mile in repairing it, putting it back into shape and applying a coat of asphaltic oil. When it is remembered that this road is in a sparsely settled country district, merely part of the main line between the Connecticut Valley and Berkshire County, and that nevertheless there is sufficient automobile travel to make oiling it an absolute necessity for its preservation before it has been used one year, it will be realized that some such treatment of macadam roads will have to be adopted over a large percentage of the state highways in the commonwealth. This treatment costs all the way from $500 to $1,200 a mile, according to the width coated, the length of haul, material available and the class and character of the bituminous binder that it is necessary or advisable to use.

The strongest evidence of the fact that motor travel has injured roads of the water-bound broken-stone type is the increase in the cost of their maintenance, both in this country and abroad, since they have been used by automobiles, in regard to which a few data, among the large number available, are of interest.

At a conference of the governors and chief highway officials of the New England states, called together at Boston by Governor Guild, of Massachusetts, in 1909, Mr. Harold Parker, chairman of the Massachusetts Highway Association, stated that

> Up to the year 1907 the cost per mile for maintenance of the Massachusetts state highways was not far from $100.

Since the advent of automobiles, particularly those capable of being operated at high speeds, it has become evident that $100 a mile a year is wholly inadequate for the maintenance of macadam roads, even if they be only of the width of the Massachusetts state highways, and that in order to keep such stone roads in perfectly good condition at least $300 a mile a year should be provided.

Figures in the possession of the Massachusetts Highway Commission show that about 53 per cent. of the destruction of state highways is due to automobiles. In seven counties near London, England, the percentage of increased cost of maintenance, due to automobiles, has been recently reported to be from 22 to 77 per cent., and this condition is probably more or less the same throughout England.

Mr. Compton, county surveyor of West Cornwall, England, reported in 1910 that in 41 counties the cost of maintenance of broken-stone roads had increased in ten years, since the advent of the self-propelled vehicle, forty-one per cent.

Mr. F. C. Carpenter, county surveyor of the West Riding of Yorkshire, stated at the First International Road Congress at Paris in 1908, that the average cost of maintenance of the roads in his district in 1890 was $482 per mile, but at that time had increased to $798, reaching in some cases as high as $3,900, while in others it was as low as $73. On the average it was $1,120 for urban roads and $584 for rural roads. He attributed the greatly increased cost in later years to the use of the roads by motor vehicles.

These conditions have been generally recognized elsewhere, both at home and abroad. The Route Nationales in France, reputed to be the finest roads in the world, especially those built of the softer limestones in southern France, have been so destroyed by motors that their maintenance, at any reasonable cost, as water-bound roads have become almost impossible.

These facts are sufficient to show the damage that motor vehicles are doing to our roads of the water-bound type, but it must be remembered that if the traffic consisting of horse-drawn vehicles had in itself increased to the same extent as the number of motor cars now using our roads, the cost of maintenance would have increased to a large extent. Before 1900 there was no demand for trunk line roads to be used by horse-drawn vehicles in the same way that they are now used by motors.

The number of self-propelled vehicles is increasing every year. Mr. Maybury, county surveyor of Kent, England, states that the increase in England in the year ending December 31, 1910, was no less than 36,935 and that this is more than likely to be maintained. In New York State more than 81,000 were licensed in 1910, in Massachusetts over 35,000. In the latter state more than one third of its vehicles are motor driven. On some of the roads near Boston automobiles furnish more than sixty per cent. of the traffic, and, during the summer, ninety per cent. of the vehicles used on the leading state roads

were of the motor car variety. The conditions in both countries are seen to be the same. Lord Montagu, of Beaulieu, has calculated that the amount of gasoline used in motors in England in the year 1910 was sufficient, at 15 miles travel per gallon to represent a mileage of 600,000,000, and Mr. Maybury says: "What are we engineers doing to meet this revolution in traffic?"

The very general answer to Mr. Maybury's question is that some form of bituminous binder must be used, either in or on the surface of the road to enable it to resist the destructive action of the motor vehicle. This was the conclusion reached at the two International Road Congresses held in 1908 and 1910. The water-bound broken-stone road is a thing of the past on our main arteries of travel which are carrying the present enormous motor traffic.

In working out the problem of a new type of road construction in which some form of bitumen is employed as a binding or surfacing material science can, and is, taking an important part. Fortunately for the past twenty-five years or more, the native solid bitumens, the liquid forms and their surrogates, the tars, have been studied very thoroughly as to their character and in their application to the construction of street pavements. It is not, therefore, difficult, for one who has had an extended experience, to apply the knowledge gained thereby to the construction with the same materials, of country highways of broken stone. The contribution which science has offered to the solution of the road problem in this direction is, therefore, important, while it supplies at the same time means of controlling the uniformity of the binding materials in use and determining the fact that any particular bitumen is of suitable character for the purpose to which it is to be applied. For the collection of these data and also, to a great extent, for their interpretation the highway engineer is dependent on the chemist, who is, therefore, becoming a considerable factor in successful road building.

Bitumen is a native material, that is to say, it is found in nature. The by-products of industrial operations, such as tar from the manufacture of illuminating gas and coke ovens, is not bitumen in the acceptation of the word as it was originally applied by the Latin writers. Coal tar is a bituminous substance merely from its resemblance to bitumen.

Bitumen is a mixture of hydrocarbons and their derivatives and may be gaseous, liquid, a very viscous liquid, sometimes called a maltha, or a solid. These hydrocarbons may be representatives of very different series, each having its own peculiar character, both chemical and physical, or a bitumen may be made up of hydrocarbons of different series. The value of any bitumen or combination of bitumens for road construction depends on the series of hydrocarbons and their derivatives,

more particularly the sulphur compounds, of which it is composed. The consistency of such material and its suitability in this regard for use as a road binder is further dependent on the relative proportions of liquid and solid bitumens of which it is composed. It is, of course, the province of the chemist to determine these characteristics for all bitumens proposed for use in road construction, and to interpret the result in the light of practical experience.

From the point of view of their solubility or insolubility in petroleum naphtha the liquid and solid bitumens in use in bituminous highway construction are composed of two components, one of which has been arbitrarily named as a class petrolenes, soluble in naphtha, and the other, asphaltenes, insoluble in naphtha. The one consists of the liquid and the other of the solid components. Whatever value a bitumen may have as a binding material for highway construction, is due to the presence and the character of the petrolenes. The solid material in itself has no binding power, but by its solution in or mixture with the petrolenes it gives to the latter their binding power, and also adds to their stability.

The value of a bitumen as a road binder will further depend upon the character of the petrolenes which it contains. If the petrolenes are of a sticky nature, the particular bitumen will be adhesive and cementitious, whereas if they are merely oily and not sticky, the material will lack in cementitious properties. The asphaltenes impart cohesiveness as distinguished from adhesiveness, and supply body or stability, as has been said, to the binding material. As an example it may be cited that the heavy residuum left on the distillation of paraffine petroleums in the preparation of burning and lubricating oils, consists of practically 100 per cent. petrolenes, but these petrolenes are oily and not sticky and adhesive. The same is true of any of the preparations from paraffine petroleums or petroleums containing a considerable amount of hydrocarbons of the paraffine series. It is not in itself a suitable binding material for highway construction as appears, not only for the reasons given, but by its behavior in actual use. The petroleums derived from the asphaltic oils, on the contrary, such as those of Trinidad, California and Mexico, are of a much more sticky character, and are not only in themselves, when reduced to a proper consistency, more suitable for a binding material, but are particularly desirable when used to soften solid and harder bitumens, known as asphalts, which possess great cohesiveness, but are wanting in cementing properties. The relative proportions of sticky petrolenes and cohesive asphaltenes is the most important element in bitumens which are used in the construction of asphalt pavements and bituminous highways. It has been found that the asphalt cement, that is to say, a solid asphalt combined with a suitable flux to provide the proper consistency for practical use, if it

contains less than 15 per cent. of asphaltenes will lack cohesiveness and stability or body, while, on the other hand, if it contains less than 70 per cent. of petroleum it will not be sufficiently adhesive. Even with the proper proportion of petrolenes and asphaltenes a bitumen may still be valueless as a cement, if the petrolenes are not of a proper character, that is to say, not sticky. These are all facts to be determined by the chemist, and his contributions to the subject have been of the greatest importance to the development of bituminous highway construction. The characteristics which he determines may be summarized as follows:

1. *General Characteristics.*—The series of hydrocarbons of which the bitumen is composed for the purpose of comparing it with those in standard materials.

2. *Purity.*—The amount of bitumen apart from the mineral or other matter, with which it may be contaminated, to regulate the amount of it which should be used under various conditions.

3. *Adhesiveness.*—Arrived at from a determination of the specific gravity of the bitumen, its solubility in naphtha, the amount of paraffine scale which it contains, this being evidence of the facts that paraffine petroleums are present in the material or absent, and its ductility or extent to which a small test piece can be elongated under tension without fracture.

4. *Cohesiveness.*—Determined by the percentage of asphaltenes which the material contains, and by the residual coke remaining after ignition of the material in absence of air, which bears a close relation to the percentages of asphaltenes present.

5. *Consistency.*—Determined by the depth to which a weighted needle will penetrate into the material, under a definite weight, at a definite temperature, during a definite period of time.

6. *Viscosity.*—Determined by the rate at which the material will flow through an aperture of definite size, at a definite temperature, in a definite period of time.

7. *Capacity to Resist Temperature at Which it Becomes Sufficiently Liquid to be Used in Actual Construction.*—Determined by the volatilization of the material when exposed for a definite length of time in a definite amount, to the high temperature at which the materials would be used.

8. *Safety.*—Determined by the temperature at which the vapor arising from the material at high temperatures, such as those used in manipulating it, will flash or take fire.

Determination by the chemist of the above characteristics and comparison of them with well-known standards enables him to say whether the bitumen in hand possesses those which have been recognized as desirable in similar materials which have been subjected to service tests in actual work with successful results.

The methods of making the above determinations have been elaborated during the last twenty-five years to such an extent that they may be relied on for the purpose for which they are used, although they will, no doubt, be improved in the future, as they have been, from time to time, in the past. At present they are sufficient, not only as furnishing data which will form a satisfactory basis for arriving at the character of any bituminous material, but also as a means for control of the uniformity of any supply which may be selected, and for regulating its use in actual highway construction.

From what has been said it can be seen that the rôle of the chemist in highway construction to-day, where bituminous materials are becoming so important an element of it, is an important one, that science can contribute much to the improvement of highway construction, and that these contributions should not be neglected where it is proposed to do the highest type of work, and to produce a highway surface which shall resist the heavy travel to which they have been subjected since the advent of the motor car.

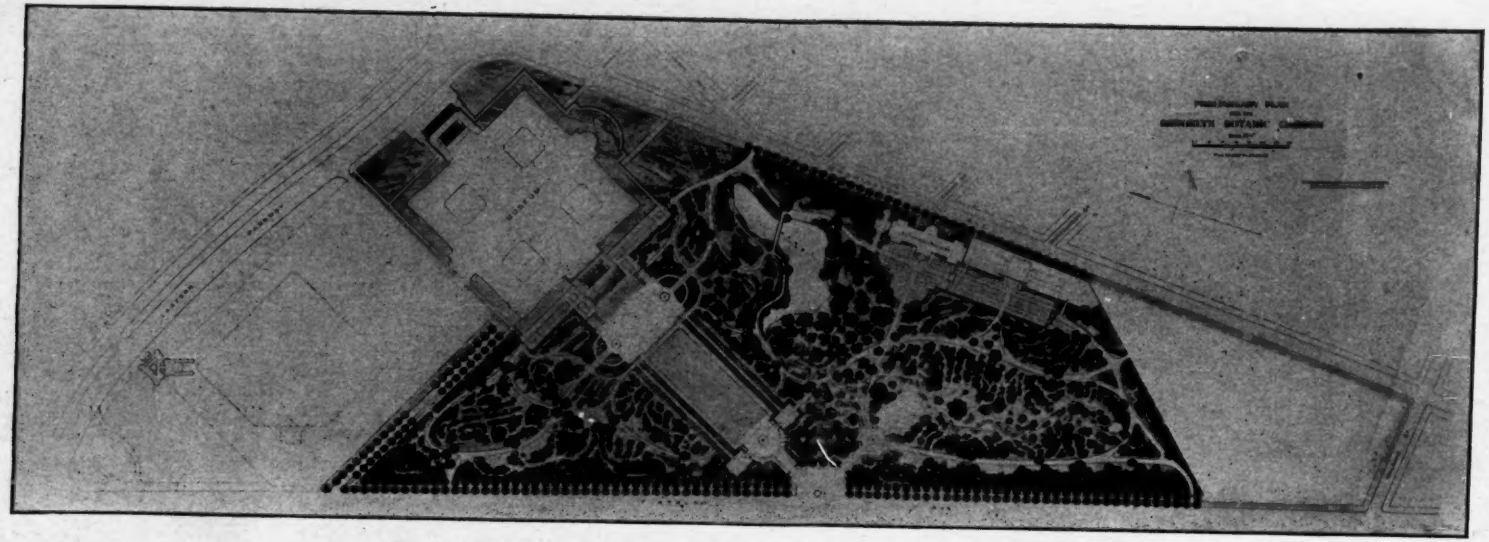

FIG. 1. BROOKLYN BOTANIC GARDEN. Preliminary plan of the grounds.

THE BROOKLYN BOTANIC GARDEN

By Dr. C. STUART GAGER
BROOKLYN BOTANIC GARDEN

THE Brooklyn Botanic Garden is a department of The Brooklyn Institute of Arts and Sciences. The institute itself, an organization of some 7,500 members, is the outgrowth of a movement starting in 1823, for the establishment in Brooklyn of a free library for apprentices. From these small beginnings, the work has gradually expanded, until now it is carried on by means of twenty-eight departments, representing various branches of art and science, and including courses of lectures and general university-extension work. During 1893–94 the establishment of a museum of arts and sciences was undertaken, and this movement has steadily developed, until now there is a large Central Museum on Eastern Parkway, beautifully housed in a building only partly completed, and in Bedford Park a wholly unique branch, the Children's Museum, described in THE POPULAR SCIENCE MONTHLY for April, 1908.

The Botanic Garden movement found its first public expression in 1897, when the Hon. George W. Brush, M.D., introduced into the state legislature of New York a bill providing for the establishment and maintenance of a botanic garden and arboretum on park lands in the city of Brooklyn. The bill, which became a law on May 18, 1897, names among other objects of the garden, the advancement of botanical science and knowledge, and the prosecution of original research therein

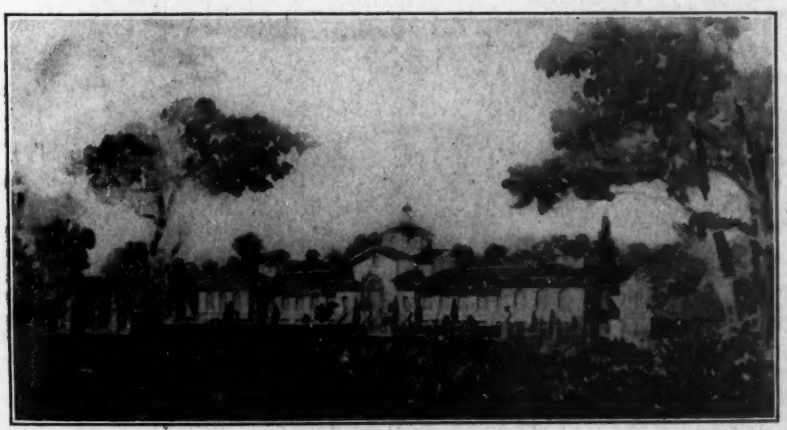

FIG. 2. LABORATORY AND ADMINISTRATION BUILDING. Front (west) elevation, facing the Garden.

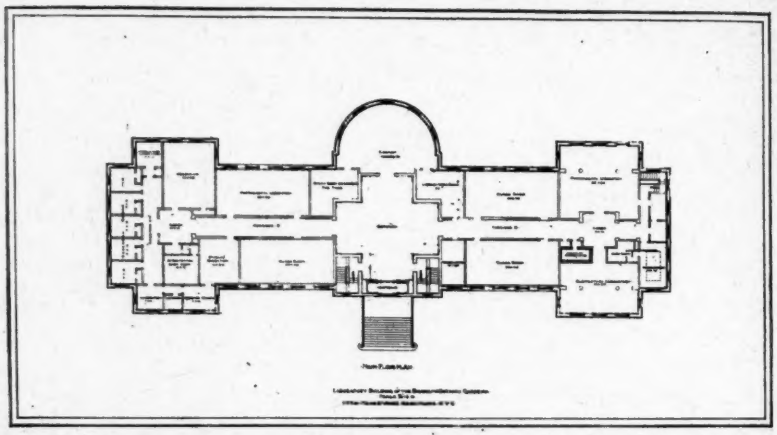

FIG. 3. LABORATORY AND ADMINISTRATION BUILDING. Main floor plan.

and in kindred subjects, the giving of instruction in the same, and the maintenance of public exhibits of a botanical nature.

The assignment of the necessary lands by the city was made contingent on the institute providing a private fund of at least $50,000. Public-spirited citizens of Brooklyn, who wish to remain anonymous, offered, in June, 1905, to give $25,000 toward this fund, and in December, 1906, this offer was doubled, thus completing the $50,000 required.

The garden grounds, turned over to the institute by the city on February 1, 1911, comprise approximately forty-three acres, lying to the south and west of the Central Museum building, in the very heart of the borough of Brooklyn. The plan of the garden, as laid out by the landscape architects, is shown in Fig. 1. The main entrance, on Flat-

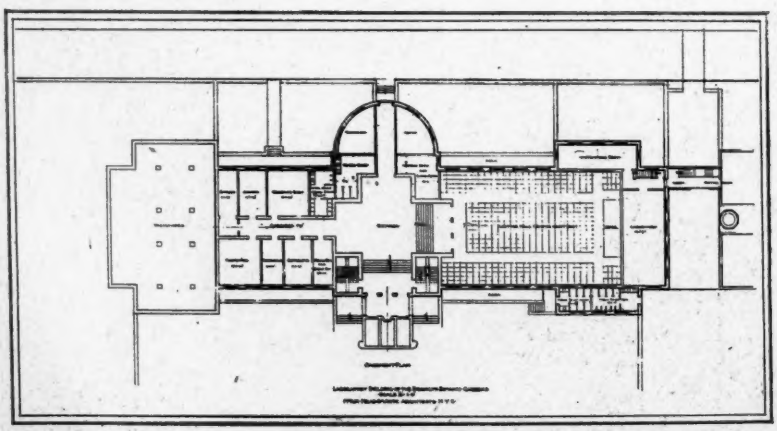

FIG. 4. LABORATORY AND ADMINISTRATION BUILDING. Plan of the basement. In the final plans the northeast "Instructors' Room" has been divided into three smaller rooms.

bush Avenue, opens northward through an esplanade to the museum building, and southward and eastward to the public conservatories and the laboratory and administration building. In the northeast corner of the garden is a lake of about three acres in area, and the adopted plans provide for a small stream leading southward through the grounds from the lake. The lake and stream together will afford excellent opportunity for aquatic planting.

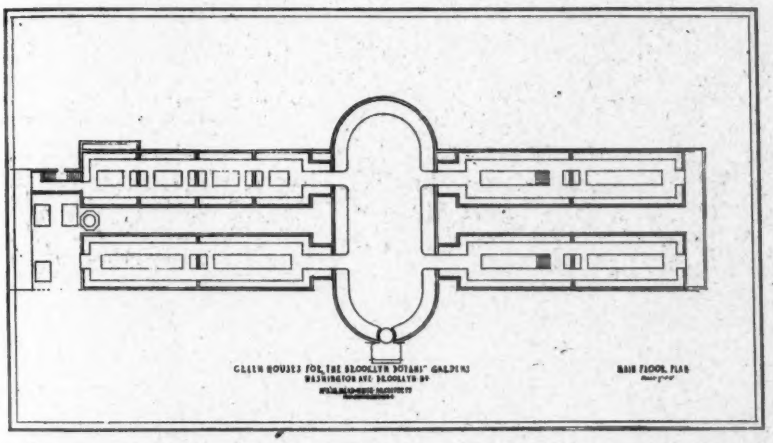

FIG. 5. CONSERVATORIES OF THE BROOKLYN BOTANIC GARDEN. Main floor plan. The northeast house (at the left) connects with the Physiological Laboratory. The division of the northeast wing into four houses is made with reference to their use for class work and for investigations.

The location of the garden is of considerable physiographic interest, for it is situated on the extreme southern margin of the terminal moraine deposited by the continental ice-sheet. As is well known, a portion of this moraine forms the so-called "backbone" of Long Island, and two or three morainal knolls give relief to the northwestern and the eastern edges of the grounds. The remainder of the garden is on the area of the overwash plain lying south of the moraine, but the surface soil is no longer of geological significance in this connection, as there have been considerable grading and top-soiling in connection with park operations. A few large glacial boulders remain in place and exposed at the surface.

The laboratory building, when completed, will be a one-story and basement structure of brick, faced with concrete, about 240 feet long, and 50 feet wide, with a maximum elevation of about 60 feet (Fig. 2). At suitable places on the exterior will be placed the names of noted botanists of the past. For this purpose there are twenty-two spaces on the frieze for names of greatest prominence, each space to contain only one name. Under each window is a panel to contain three names. The choice of names was determined by a vote of contemporary American botanists.

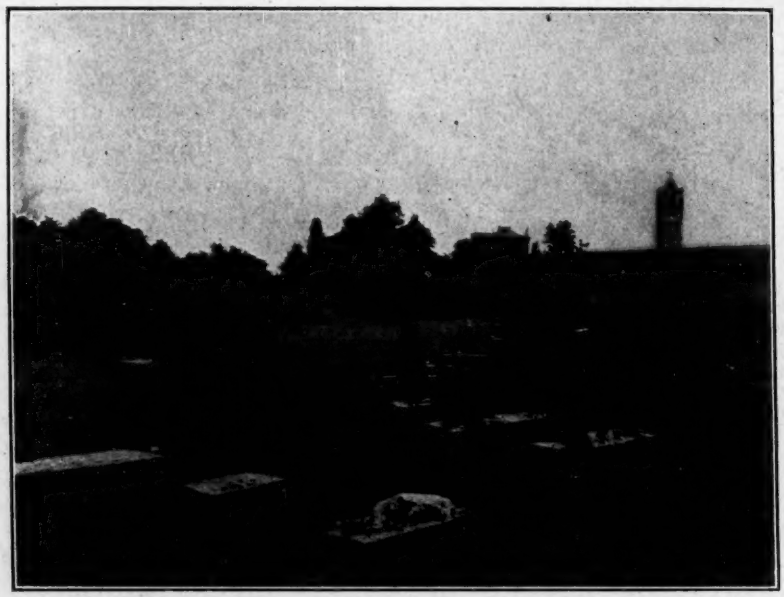

FIG. 6. NATIVE WILD FLOWER GARDEN (LOCAL FLORA SECTION) OF THE BROOKLYN BOTANIC GARDEN, AUGUST 14, 1911. A small portion of the bog shows at the extreme left. The slope at the right is now thickly planted with local flora shrubs. In the background is shown the Prospect Heights reservoir, with water tower, and the laboratory of the municipal Department of Water Supply, Gas and Electricity.

The main entrance to the laboratory building from the west or garden side opens into a central rotunda (Fig. 3). East of the rotunda is the well-lighted main library room, with an area of 1,050 square feet. Opening from this at one side is a stack room with a capacity for 10,000 volumes; at the opposite side, a librarian's work room, part of which may also be used for stacks. There is additional shelving space in the main reading room.

The portion of the building north of the central pavilion contains the public and private offices and the private laboratory of the director; a morphological laboratory 20 × 40 ft.; a herbarium room 22 × 28 ft.; a class room 20 × 40 ft.; six private research rooms 9 × 12 and 11 × 12 ft., and an experimental dark room 12 × 15 ft.

The southern wing contains two class rooms, each 20 × 40 ft.; an instructors' room 10 × 20 ft.; an elementary laboratory 23 × 34 ft.; a physiological laboratory 28 × 34 ft.; a constant-temperature room; a photographic operating room with overhead light, connecting with a photographic dark room, and two private offices for members of staff. The physiological laboratory connects with one of the wings of the conservatories, reserved for experimental work. Passage from one to the other may be had without going out of doors.

In the basement (Fig. 4) is a lecture hall with a seating capacity of about 500. At the south end are three private rooms for members of staff, and a well-lighted laboratory 18 × 37 ft. The remainder of the basement is occupied by service rooms, as shown in Fig. 4. Under the south end of the building is also a sub-basement, containing four rooms.

The conservatories (Fig. 5) consist of a central palm house 104 feet long and 45 feet wide, with two south wings and two north ones. The greatest height of the palm house is 36 feet. The south wings are each divided into two houses, each 50 × 22.5 ft., and from one of these, stairs lead down to a "mushroom" cellar. The northwest wing is like the south ones, but the northeast wing is divided into four rooms, each 25 × 22.5 ft. These rooms are reserved primarily for class use and for investigators. In the basement under the south wings are stables, a potting room, gardener's office and other service rooms.

During the spring and summer of 1911, the installation of the plantations was begun. The Local Flora Section or "native wild flower garden" (Fig. 6) was laid out and partly planted. In this section is an artificial bog (Fig. 7). The Morphological Section was also started, subdivided into a Division of External Anatomy, and a Division of Comparative Morphology. The third section planted was the Economic Garden (Fig. 8), which is of especial interest in a large city,

FIG. 7. BROOKLYN BOTANIC GARDEN. A corner of the Local Flora Section, showing the artificial bog. The large label near the center of the picture locates and describes the insectivorous plants. The labels under the edge of the shrubs designate shade-loving sorts. August 14, 1911.

where many of the visitors, especially among the children, have never seen the common food-plants outside of a grocery store, and have never seen any of the fiber and medicinal plants at all.

Aside from the labeled plantations, which in reality constitute an out-of-doors museum, and the conservatory collection, no museum will be developed in connection with the garden. The close proximity of the Central Museum building of The Brooklyn Institute of Arts and Sciences makes a separate static exhibit by the garden unnecessary, for the plans of the museum include an extensive botanical section.

On account of the ample facilities already offered in Greater New

FIG. 8. ECONOMIC SECTION OF THE BROOKLYN BOTANIC GARDEN. The first two rows of beds contain food and fodder plants; the third row, medicinal plants; the fourth row, condiments and relishes; the fifth row, fiber plants. August 14, 1911.

York for work in systematic botany, no attempt will be made to develop a systematic center at the Brooklyn Garden. Only such a herbarium will be assembled as represents the local flora, as the needs of other departments indicate, and as the proper naming and labeling of the collections makes necessary. Investigations will be confined to other subdivisions of the science than taxonomy, such as physiology, pathology, morphology, experimental evolution and phases of economic botany.

Annual city appropriations for the maintenance of such an institution as a botanic garden are, of course, justified only by the service which the garden can render to the city. In this connection it may be stated that it was the wish of those instrumental in securing the estab-

lishment of the garden that the formal teaching of botany to classes be emphasized here to a greater extent than has hitherto been customary in botanic gardens; and especially that the garden articulate in every feasible way with the botanical work of the elementary and advanced schools of the city, both public and private. Lectures and courses of lectures and laboratory courses will be offered to pupils in the city schools; to a limited extent material for class study will be provided, a system of docentry will be developed, and courses for teachers will be offered. Thus, and by means of its library, laboratories and labeled collections, indoors and out, and by its encouragement and ample provision for research, will the garden endeavor to realize its ideal of "the advancement of botany and the service of the city."

ALEXANDER VON HUMBOLDT[1]

By Dr. EDWARD F. WILLIAMS
CHICAGO, ILL.

WITH Baron von Humboldt, says the late Professor Louis Agassiz, "ends a great period in the history of science: a period to which Cuvier, Laplace, Arago, Gay-Lussac, De Candolle and Robert Brown belonged." It was a period of tireless research, of important discoveries, of brilliant generalizations. It was a period in which the specialist appeared, and secured for himself an honorable position. Yet there were men, and among them Humboldt the most distinguished of them all, who were deeply interested in all departments of science, men who sought to master at least their elementary principles and to render themselves able to judge intelligently concerning the conclusions which were reached. Since Humboldt passed away it is doubtful if any one has lived who in the extent and accuracy of his knowledge, the breadth of his vision and the soundness of his judgment can be compared with him as an equal. All the more true is it that his death in 1859 closed an era in the scientific world.

It was in this year that Charles Darwin published "The Origin of Species" and that the Fraunhofer lines of the spectrum were discovered. The theory of evolution was the outcome of studies which Darwin's book compelled the scientific world to undertake. With the full, or even partial, acceptance of that theory new methods of study have been introduced into nearly every department of learning. In the face of such a theory it has been impossible to be satisfied with the old views of history, literature, philosophy, theology, to say nothing of science. It is therefore a matter of no little interest to know what were the views of Humboldt and his co-laborers during the period above mentioned, upon which the foundation of a new era was built. For a clear and accurate statement of the scientific knowledge of his time no work is more worthy of confidence than Humboldt's "Cosmos", of which Vol. I. was published in 1845, Vol. II. in 1847, Vol. III. in 1850, Vol. IV. in 1858 and Vol. V. soon after the author's death. The earlier editions were constantly improved, and the entire edition, furnished with notes, containing extracts from private letters or publications of distinguished men which are of great interest and value, has appeared again and again. Admitting, as we must admit, that many, perhaps most of the conclusions reached in this work, have been set aside by later discoveries, the

[1] "Cosmos," Vols. I.–V., Harper & Brothers, New York.

material gathered and arranged in Volumes I. and II. will always be worthy of consideration and the methods employed in securing it will never fail to be suggestive and useful. That his opinions would require modification, and that some of them might be rejected altogether, is what Humboldt himself anticipated. He calls attention repeatedly to the fact that he and his fellow students were on the threshold of discoveries which might change the entire scientific outlook and furnish even the next generation with an immense advantage over his own.

Friedrich Heinrich Alexander von Humboldt was born at Tegel, near Berlin, on September 14, 1769. He died in Potsdam, where his house is still shown to visitors from every civilized country, on May 6, 1859. His elder brother, William, was distinguished as a statesman, diplomatist and linguist. As the founder, while minister of public instruction of the University of Berlin, he made a great contribution to the intellectual development of the German people. The father was a major in the Prussian army and had been chamberlain at the court of the king. The mother, Marie Elizabeth von Colamb, the widow of Baron von Hollande, was a woman of rare gifts. She devoted herself almost entirely to the training of her two sons, her only children, William and Alexander. As the father died when Alexander was but ten years old, the responsibility of their education fell upon her. Fortunately the family was wealthy, so that private teachers could be provided for the boys at Tegel, among them men like J. H. Camp, famous for his ability to impart knowledge; Christian Kunth, eminent in the educational world, and T. T. Engel. From Tegel the boys were sent to Berlin and put under the care of specialists, whence they were removed to the University of Frankfort on the Oder, thence to Göttingen, where Alexander studied philology and archeology under Heyne, and gave special attention to the philosophy of Kant. His natural love for science was deepened and strengthened by his association with Professor Blumenbach, one of the great men of the university. Destined for business, young Humboldt went from Göttingen to Hamburg and entered the commercial school of Bursch, where he studied modern languages with much zest and listened to lectures on banking and trade. But he soon found that his love for science was greater than his love for money-making, and for this reason, without wholly giving up the thought of a business career, he left Hamburg for the mining school at Freiburg, where he enjoyed the instruction of Werner, the geologist, of the equally famous Leopold de Buch and of Andre del Rio. In a single year he made such progress that in 1792 he was appointed director general of the mines in the district of Franconia and Aspach, with headquarters at Bayreuth. In this position he remained five years, but while faithfully discharging the duties of his official life he found time for brief visits to the Tyrol, Switzerland and Lombardy for the study of botany and geology. With George Foster, a friend of his student years,

and the person to whom, as he often declares, he owed his first impulse to the life he led later, he had previously visited England, Holland and Belgium. It was this George Foster, the companion of Captain Cook on his second voyage round the world, who suggested to Humboldt his travels and researches in the tropical world.

As an author young Humboldt had already given proof of far more than ordinary ability. At Göttingen he had written a book on the "Basalts of the Rhine," and in 1792 published a striking essay on the "Fossil Flora of Freiburg." While inspector of mines, employing the discoveries of Galvani, he published two volumes, still frequently consulted, bearing the title, "Über die gereiste Muskel- und Nervenfassen nebst Vermuthengen über den chemischen Process des Lebens in der Thier- und Pflanzenwelt," Berlin, 1797.

The death of his mother, to whom he was warmly attached, and the increase of his income made it possible for him to carry out long-cherished plans for travel and the study of nature in the tropics. Resigning his position as inspector of mines, he visited Vienna and Paris for special studies and for the purchase of instruments and instruction in their use. In Paris he met Gay-Lussac, Laplace, Arago, Berthollet, and Aimé Bonpland, a young botanist who became his companion in travel and research, and in whom he found the friend and assistant whom he needed. Failing in their attempts to make satisfactory arrangements for explorations in Egypt and Central Africa, the two men finally accepted the protection and assistance of Spain, and decided to devote themselves to the study of the physiognomy, the plant and animal life of the tropical regions of South and Central America and Mexico. At the head of an expedition which in equipment and retinue had hardly been equalled since the days of Alexander the Great the two men sailed from La Coruña in northwestern Spain, June 5, 1799, and landed at Bordeaux, France, on their return home, June 3, 1804. During their absence they had explored Venezuela, ascended the Orinoco 1,800 miles and learned that its head waters are connected with those of the Amazon, had sailed up the Magdalena, settled for a time at Quito and made themselves thoroughly acquainted with the west coast of South America almost to the southern limits of Peru. They had ascended Chimborazo to the height of 19,000 feet, had studied carefully the crater of Cotopaxi and learned all that could be learned at the time concerning the physiognomy of the country. They had studied the forms of life, animal and floral, observed the variations of temperature at different levels above the sea, the arrangements of the mountain chains, the situation and character of volcanoes, active and extinct. They had studied under favorable conditions the celestial phenomena peculiar to the tropical regions and given special attention to the zodiacal light. From the people and their own observation, they had learned all they could learn concerning the country, its civilization and

history, its institutions of culture and religion, its resources, agricultural and pastoral, its mines, its timber and its capacity under more favorable conditions to contribute to the sum of human happiness. They had made use of the discoveries of previous visitors, like Condamine and Bourguer of the Academy of Sciences in Paris, who were in the country from 1742 to 1747, and by their observations had made it easier for future explorers, like Boussingault, who followed them twenty-three years later, to profit by their stay in the country. Incidentally Humboldt learned the value of quinine as a medicine, and is to be credited, in part at least, with having made it known in Europe. He and his companions ascertained the location of places by astronomical methods, noted accurately the movements of the barometer so important in determining the character of the climate, and did not overlook at all the botany, the mineralogy, the geology, or even the archeology of the country. Having completed their observations in South America and made a vast collection of specimens of various sorts, which they sent to Paris, they sailed in 1803 for Acapulco, Mexico, where in studies of that country and of Central America they spent nearly a year. Only a few weeks were given to the United States, whence they sailed directly to Bordeaux, France.

Having reported to the King of Prussia and passed nearly two years in and around Berlin, Humboldt obtained leave to visit Paris and arrange for the publication of the results of his explorations. The work which he had thought would occupy him possibly three or four years extended to twenty and even then was unfinished. In Paris, of which he was extremely fond, he associated himself with some of the ablest living scientists of France and with their assistance gave to the world, during the years 1807–1827, thirty volumes of description and discovery. If the scientific world was astonished at the contents of these volumes and the regularity with which they appeared, it soon found that the knowledge for which Humboldt made himself responsible was as accurate as it was extensive. Many of these volumes, in which more than two thousand very costly illustrations appeared, were written by Humboldt's associates, but no one of them left the press without his oversight and approval. It is little wonder that his name was in high repute in every part of the civilized world, that he was chosen a member of nearly every learned society in Europe, or that by general consent he was accounted the first scientific man of the age. This reputation, so early acquired, he retained till his death. Nor were his honors derived from the scientific world alone. While living in Paris he was often employed by his king as a diplomat, and with great profit, for he was a favorite at the court and in the best social circles of the city. A little above medium height, with regular features, beaming eyes, a rare charm of manner, and with a capacity for friendship rarely equalled (it is said

he never lost a friend) he was almost as famous for his social as for his scientific victories. Yet he never married.

It was with real sorrow that he obeyed the command of his king and left his dearly loved Paris to pass the remainder of his life in Potsdam. He was in the fifty-ninth year of his age, in perfect health and deeply interested in every department of learning as well as in those special fields to which he had given personal attention. A home was provided for him at Potsdam, a liberal salary paid him regularly, so that, barring the demands which the king made upon him for diplomatic services (and these were not infrequent), as a companion of his official visits, or as a visitor at the palace, he was free to pursue his studies. The German public, proud of his renown, rejoiced in his return to his native land and read with increasing interest and enthusiasm whatever came from his pen.

His lectures at Berlin in the winter of 1827 and 1828, which formed the basis of "Cosmos," were heard with astonishment and delight.

A man like Humboldt, so widely known and so thoroughly trained as an explorer and observer, could not long be permitted to remain quiet in any one place. At the request of the Czar of Russia, under his protection and at his expense, with Ehrenberg, the microscopist, Gustav Rose, the chemist, and Menscherlisch, an engineer, he made a rapid but intelligent survey of Asiatic Russia, giving particular attention to the Ural and Aral Mountain chains. It was on this journey that diamonds were discovered in the Ural Mountains and secured to the government for its control and profit. Ehrenberg and Rose published separate accounts of this journey and Humboldt's "Central Asia" is an enlargement and revision of his first report, which appeared simply as a fragment, on the geology and mineralogy of the country.

While in Paris he had experimented with Gay-Lussac on the nature and qualities of gas, and with him as a companion had visited Rome, where his brother William was the Prussian minister, in order to study magnetism. It would take a good-sized volume to give an account of the various services he rendered the king, and of the journeys he made as a diplomat, nearly always with success, and in the interest of science. He was in the seventy-sixth year of his age when he made public his intention of writing that great work of his life known as "Cosmos." Previous treatises he looked upon as preliminary sketches compared with the work he would now compose and in which he would try to give an accurate and sufficiently full account of all existing scientific knowledge. In this work, while presenting general rather than detailed conclusions or statements, he would show that nature, in spite of her seeming complexity, is yet a unit and governed by a definite and well-ordered plan. A master of the materials furnished by the most eminent scientists of the day, without claiming for himself to be an authority in any single department of science, he believed himself better fitted by reason of

his acquirements, his acquaintance with the scientific men of every country, his wealth, his relation to the king, his leisure, than any other living man to write the book he proposed. He had the promise of assistance from the representatives of all the sciences, and through private correspondence and their publications could obtain from them the latest and most accurate information on the topics he wished to discuss. It is not strange that one of the striking features of "Cosmos" should be its notes, which contain extracts in many cases from private letters and from publications in journals rarely seen, by men whose names Humboldt seems to take pleasure in mentioning, and to whom he never fails to give full credit.

Yet, modest as he is in reference to his own acquirements, he may justly be regarded the founder of the sciences of meteorology, terrestrial magnetism and the physics of the sea. To him more than to any man of his time is due the interest in the study of the currents of the air. It was at his suggestion and after his plans that the Russian government established, from one end of its dominions to the other, stations for the observation and record of magnetic phenomena. It was through his influence that England did the same in her territories, and that other countries have to a certain extent followed these examples. Perhaps it may be added that he is the founder of the science of geodesy. At any rate he was the first to give a full and complete picture of the physical features of the earth and to call attention to the effect of these features and of the temperature of a country upon its inhabitants. The tracing of isothermal lines is due to him. In fact, during his life few new steps were taken or changes made in scientific study without suggestions from him or consultations with him. One of his characteristics was his fondness for young men, and the pleasure he took in aiding them. If he was a little vain, apparently somewhat self conscious, it was by no means unnatural. The friend of kings, a social lion, a successful diplomat, a classical scholar of nearly the first rank, well versed in history, ancient, medieval and modern, at home in modern languages, a master of the best literature of the century, through his brother William, well-acquainted with oriental literature and with the conclusions of the comparative study of language, the pride of the German people, recognized on all sides as worthy of the highest honor a man can receive from any source whatever, it would be contrary to nature not to be influenced to some extent by the flattery which came from every side. Without an exception the scholars of Europe recognized his greatness and his eminent fitness for the work he proposed to undertake. The work had been on his mind for at least twenty years. For it he had gathered material, had pursued special studies, made special visits, cultivated the friendship of eminent men, by constant thought formed the plan which he finally carried out, of presenting in clear readable form an account of all that had been discovered and accepted as worthy of belief in the scien-

tific world. As we think of this aged but vigorous man sitting down in his study in Potsdam with the learning of the world at his command, with every literary or scientific man in Germany or France or Italy or Russia ready to furnish any information he might ask, we can not help sympathizing with him in his conviction that he was indeed the best man living to write a book like "Cosmos." The reports published in Paris had, in his eyes, only prepared the way for the generalizations he would now make. Yet to the ordinary man they seemed complete in themselves. They covered a vast field of exploration and study. They had engaged the labors of some of the most eminent men in their departments for twenty years. These reports, arranged in six sections filled thirty volumes. These sections are as follows, viz.,

I. Historical, Geographical and Physical Atlas; Views of the Cordilleras and of the Native Peoples of America.

II. Observations on Comparative Anatomy and Zoology.

III. Political Essay on the Kingdom of New Spain.

IV. Astronomical Observations; Trigometrical and Barometrical Measurements.

V. Essay on Geological Basiography.

VI. Equatorial Plants.

In the International Encyclopedia it is asserted that Vols. I.–XIV. were written by C. S. Kunth, the botanist. They treat of botany almost exclusively. On the South American journey hundreds of new species of plants were discovered and described, and specimens of them sent to Paris. The general title of this extensive work was "Voyage aux regions equinoxiales du Noveau Continent fait en 1799 . . . 1804 par Alexandre de Humboldt et Aimé Bonpland." Volumes XV. and XVI. are an "atlas pittoresque."

With the exception of Volume XX. which is devoted to plants, Volumes XVII.–XXII. are occupied with physical geography, geognosy and astronomy. Volumes XXIII. and XXIV. are given to zoology, and Volumes XXV. and XXVI. to a description of the countries of Spanish America. Volumes XXVII. to XXX. contain Humboldt's own narrative and notes upon the countries visited. Unfortunately this narrative was never quite finished. The original work contained the "Essai politique sur royaume de la Noveau Espagñol," the "Essai politique sur l'isle de Cuba," and "Vues des Cordilleries." Special sections of this immense work appeared from time to time under individual titles, and as composed by specialists of distinction. Humboldt's "Ansichten der Natur" was very popular in Germany, as was an edition of his works published in 1864–1866. In Bruhn's "Life of Humboldt," it is shown that he made special contributions to petrography, vulcanology and seismology, that he pointed out the effect upon civilization of the cultivation of the soil in different climates, and drew attention to the languages, architecture and customs of the ancient peoples

of South and Central America and Mexico. He was the first, so it is claimed, to mark the decrease in intensity of magnetic force from the poles to the equator. At any rate, his journey to the tropical possessions of Spain in the new world gave a very decided impulse to the study of natural history.

It is not strange that a man with his extensive knowledge, his varied experience as a traveler and the resources of the scientific and literary world at his disposal should desire to write and publish a work that should set forth in clear and accurate form all that in his time was known of the earth and the celestial bodies. If any man was ever justified in the belief that he could satisfy his ambition in this respect it was Alexander von Humboldt at the age of seventy-six.

"Cosmos" is a history in outline of the physical contemplation of the universe. Its aim is to show the unity of the universe. It is not a history of the natural sciences as such, rather an attempt to point out the close connection of all the forces of nature. To do this all possible sources of information are laid under tribute. In his study of what has been done and is now known, Humboldt pledges himself to follow three laws, or to be guided in his thought and writing, by three principles: viz.,

1. To show the efforts of reason, through meditation upon phenomena to obtain a correct knowledge of natural laws.

2. To consider events which have suddenly enlarged the horizon of observation.

3. To show what has been the result in the enlargement of the fields of human knowledge through the discovery of new means of sensuous perception, or of new organs, or instruments by means of which we are brought into closer touch with terrestrial and celestial objects. Thus in the telescope and the microscope we have new organs of perception.

Starting from the basin of the Mediterranean, with its three contiguous closed seas and its three peninsulas, Spain, Italy and Greece, the discoveries made by voyages to other countries are named, and the fact stated that the earliest civilizations were developed in countries rich in rivers, as Egypt, Messopotamia, India and China. The author takes pains to emphasize the exceptional men who lead in new movements in travel, who make startling and important discoveries. Nor does he overlook the events which mark the beginning of new eras in the world's history. He has the rare faculty of making us see how striking contemporaneous events often are. For example, when Columbus discovered America, Copernicus was studying astronomy with Brudzewski in the University of Cracow. The rapid extension of knowledge at the beginning of the seventeenth century was due to the studies and discoveries of Galileo and Kepler, at its close to those of Newton and Leibnitz. It was in this century that the problems of

light, heat, magnetism, double refraction and the polarization of light were partially solved. Some traces of a knowledge of the results of the interference of light are seen in the works of Grimaldi, Hooke, William Gilbert and Halley. But it was the discovery of the calculus by Newton and Leibnitz, and its use by scientific men, that the new impulse was given to the study of astronomy and physics. Some of the marked periods in history may be mentioned. One of these periods was that of the Argonautic Expedition under Jason in search of the Golden Fleece which took place about 1200 B.C. Another was the passage of Europeans into the regions of the Euxine and the settlements made there by the Greeks; another the expeditions of Alexander the Great, whose campaigns have been called scientific as well as military. Another period of great importance is marked by the growth of scientific interest, especially in Egypt, under the Ptolemies, and still another by the dominion of Rome and the influence of the Cæsars. In the Middle Ages, Arabs who had absorbed and added to the learning of the Greeks, brought it back from Bactria, a kingdom which lasted 116 years, to western Europe and thus in the fifteenth century became the pioneers in the new world of awakened thought. Phœnicians led in the early voyages of explorations. The Greeks followed and established colonies on the coasts of Asia Minor and on the southern shores of the Black Sea. Wherever Romans went they remained as conquerors. From the Phœnicians we have few descriptions of nature. From Roman writers like Cicero, Ovid, Livy, Cæsar, there are more. There are some also in the writings of the Greeks from Homer and Hesiod down, but for the most part the interest centers in man, not in the beauty or striking features of the region in which he lives. The Hebrews are not insensible to the importance of natural scenery upon the character of men, nor are they unable to give vivid utterance to the impression which sublime scenery, as witness Ps. 104, makes upon them. From the christian fathers, as in the writings of Basil the Great, whom Humboldt especially admired, we have many descriptions, though even here the human element is always of prime importance. The Aryan races, natives of India and Persia, recognize the charms of nature, but still *men* are the objects upon which interest in their writing rests. In the early Italian writers, and in the poets to the time of Petrarch and Dante, there is evidence of a growing fondness for scenes of natural beauty. Calderon is a representative of many a Spanish poet who does not think it beneath his dignity to convey to others some of the impressions which the vision of a lovely landscape has made upon the mind. Camoens in his Lusiad proves that this is true for Portugal also. In the fourteenth and fifteenth centuries travelers were careful to describe the strangeness and at the same time the attractions of the regions they visited. Thus the way was prepared for Columbus, who had the ability to give a description in a single luminous sentence which lingers in the mem-

ory, and creates a desire to see for oneself the places of which he writes. Humboldt thinks that landscape painting was not without an influence on early attempts to write out descriptions of nature. Landscape gardening made its contributions also, through the rare plants and trees, flowers and fruits, it presented to the eye. But the work of others is only an incentive to Humboldt to see with his own eyes and to set forth in picturesque language the features and striking characteristics of the countries in which he has lived. In doing this he is careful to show the effect of climate and the physical features of a country upon the well-being of men, for even he can not forget that it is for man that this world exists, and that it is to be studied for his sake and not for itself alone.

Astronomy, as known prior to the second half of the nineteenth century, receives extensive treatment in the "Cosmos." With its history and with the character and acquirements of the men who from the days of Aristarchus of Samos had been scanning the heavens and penetrating into the secrets of the starry worlds, Humboldt had made himself thoroughly familiar. What would he have said had he been as familiar with the principles of astrophysics? More ready than ever, assuredly he would have been, to assert his belief that we are standing on the threshold of a new era in scientific knowledge, and of discoveries which can not fail greatly to extend the horizon of our vision.

If he is careful to give credit to the early scientists with their limited acquirements, he is none the less so in his reference to the men of his day. Of Ehrenburg, his companion on his Asiatic journey, and a friend from whom he often received aid, he speaks as "the greatest microscopist of the age," "the highest authority in the study of microscopic organisms." Ehrenburg was one of the young men in whom Humboldt took deep interest. He was born at Delitsch in 1795 and died in Berlin, 1876. From 1820 to 1825 he was engaged in explorations in Egypt, Abyssinia and Palestine, and from 1838 to 1854 gave his attention almost exclusively to the study of microscopic organisms. For a translation from a Japanese Encyclopedia of an article on volcanoes Humboldt gives grateful recognition to Stanislaus Julien and prints it in full in Vol. V. of the "Cosmos." He refers to his brother William, whose death he mourned as long as he lived, as half his life, as an authority, as his treatise on the Kawi language shows, in the science of the comparative study of languages. Professor Waagen, of whose information he often makes use, the director of the gallery of painting in Berlin, is declared to be "a profound and cautious connoiseur of art." Generous praise is given Ottfried Müller, author of the "Archeologie der Kunst." Of Goethe and Schiller he speaks in terms which not only indicate his high esteem for their abilities, but the intimacy of his relations with them. Ludwig Tieck is an honored correspondent who has answered his questions concerning Calderon's and Shakespeare's de-

scriptions of nature. Of August de Chateaubriand, who died July 4, 1848, he speaks as his "old friend, famous for his descriptive powers." Nor does he fail to speak of Arago in the most affectionate terms, quotations from whose letters fill many pages of notes, and for whose attainments he had profound respect.

Humboldt begins his work with a description of celestial phenomena and then comes down to the earth. He refers with respect to the labors of Hipparchus, Eratosthenes and Euclid, as of mathematicians of the first rank. He credits Aristarchus of Samos with having anticipated Copernicus in his theory of the universe. He recognizes the value of Strabo's geography, written after its author had entered his eighty-third year, and makes use of the works of the Plinys, the elder and the younger. To Hipparchus of Sicily, and Galen of Pergamos, physician and anatomist, he refers as men of the highest attainments. He praises the Arabs not only for their observations of the heavens and their careful mathematical calculations, but for their skill in chemistry and their experiments in order to discover its value in medicine. He says they were acquainted with many of the qualities and uses of sulphuric and nitric acid, and were aware of the fact that bodies can be decomposed and reunited. He is at pains to show how nearly related to each other most discoveries are, and that they are made in almost every instance by men who miss only by a little the discovery of some great truth which a little while after, other more fortunate men see. Preparations, Humboldt tells us, for the voyages of great sailors just before Columbus were made in the twelfth century. Three men in the thirteenth century, Roger Bacon, Albertus Magnus and Vincentius of Beauvais, would have been eminent in any century. As independent thinkers, Duns Scotus, William of Occam and Nicolas of Cusa led the thought of the world from the time of Ramus, Campanella and Bruno to Descartes. It was in 1250 that Vincentius wrote his "Secula Naturæ" for the use of St. Louis and his queen Margaret. This and other works of his were forerunners of of the "Margarita Philosophia" of Father Reisch, published in 1486, a book which Humboldt praises and of which he made some use and which he declares was instrumental in diffusing knowledge in the last half of the fifteenth century. Of the writings of Father Joseph Acosta, the Jesuit who published his "Natural History of the Indies" in 1590, it is enough to say that they prepared the way for works of Vossius, which Newton used, and in which Humboldt finds the groundwork of physical geography. Many events which were of importance in his day Humboldt traces back to the fifteenth and the beginning of the sixteenth centuries. These are the doubling of the Cape of Good Hope by Vasco di Gama, the discovery of America by Columbus, the voyages of Amerigo Vespucci and his son, and Magellan's circumnavigation of the globe. That same period witnessed a rare manifestation of intellectual power as well as the growth

of a desire for religious freedom. It was in this period that the Laocoon, the Torso of Hercules, the Apollo Belvidere, the Medicean Venus were rediscovered. Michael Angelo was living in Rome, Leonardo da Vinci in Venice. It was the period of Titian and Raphael, of Holbein and Albert Dürer. Fourteen years after the discovery of the new world, or in the year that its discoverer died (1507), Copernicus made known his system of the world. Almost immediately followed an era of invention and the skilful use of instruments of research. New wonders in the heavens were constantly appearing. The results of mathematical calculations made astronomy an exact science. The law of gravitation, Kepler's laws of motion, knowledge of the pressure of the atmosphere, of the propagation of light, its laws of refraction and polarization, the radiation of heat, electro-magnetism, reentering currents, vibration chords, capillary attraction, in their discovery and in the increase of knowledge concerning their nature and importance, are all closely connected. Galileo, Lord Bacon, Tycho Brahe, Descartes, Huyghens, Fermat, are more nearly related to each other in the work they each accomplish than is generally understood.

A list of some of the subjects treated in Volume I. of "Cosmos" will give a hint of the wealth of learning it contains and of the ability of the author to bring together a vast amount of knowledge on a great variety of topics without confusing his readers or for a moment permitting them to lose sight of his purpose to show how all knowledge is related and that the heavens and the earth belong to the same general plan, and are under the government of a single intelligent will. Beginning with a review of what is known of celestial phenomena, he comes down to those which are terrestrial in their character. Under celestial phenomena sidereal systems are treated as well as the solar system. Comets are carefully considered, aerolites, also, the zodiacal light and the milky way with its starless openings. Under terrestrial phenomena are grouped such subjects as the distribution of mountain chains, great plains, arid and fertile, oceans, inland seas, lakes, rivers, the figure of the earth, its internal heat, terrestrial magnetism, the aurora borealis, geognostic phenomena, earthquakes, gaseous emanations, hot springs, salses, volcanoes, isolated, in groups, and along certain lines, paleontology, geognostic periods in the earth's history with reference to certain marked changes in the physical features of the globe, atmospheric pressure, meteorology, the snow line of mountains, hygrometry, atmospheric electricity, organic life, the geographical distribution of plants and animals, of races of men and of language. One can see from this enumeration of titles how broad is the outlook over the world of knowledge in this little volume of less than 400 duodecimo pages. On every subject treated Humboldt either gives his own opinions or those of men whom he deems competent to speak. On astronomy we have not only what the ancients have thought, and the astrol-

ogists, but what the Herschells, Maedler, Arago, Leverrier, Laplace, Bessel of Königsberg, an authority on comets, and Faye, discovered and taught. Aerolites, shooting stars, fire balls, meteoric stones, are given extensive treatment. Aerolites are said to be "small bodies revolving with planetary velocity, and in obedience to the law of general gravity, in conic sections round the sun." Showers of shooting stars were observed by Humboldt and his companions in Cumana, S. A., in 1799 and in 1832–33 by Professor Denison Olmstead, of New Haven, Ct. To the consideration of this phenomena men like Brandes, Benzenberg, Bessel, Arago, Eduard Biot, Poisson, the mathematician, and Berzelius, the chemist, gave much time and thought.

The first person to observe and report upon the zodiacal light, according to Humboldt, was Dominique Cassini, of Bologna. He published his views in 1668. About this time the phenomenon was observed in Persia by Chardin, the traveler. Laplace, Schubert, Poisson and Sir John Herschell regarded the phenomenon with deep interest and sought a satisfactory solution for it. From Sir John Herschell at the Cape of Good Hope came the suggestion that the milky way could be broken up into well-defined sections and that with sufficiently powerful telescopes all its nebulæ could be resolved into stars. Humboldt himself directs attention to so-called "starless openings" in the milky way through which one looks out into empty space.

Before Humboldt died there were a large number of competent observers of terrestrial phenomena. It was taken for granted as needing no proof that the interior of the earth is liquid and of high temperature, and that this heated melted matter has acted, and continues to act, upon the surface of the earth. It was believed that the depths of the sea correspond in general with the heights of the mountains, and that our power to study the surface of the earth is limited to about the distance of 48,000 feet. The history of volcanoes, traced from the days of Plato, Aristotle, Ovid, Pliny to Daubeny, whose treatise on the subject (Paris, 1848) Humboldt accepts as the best ever written, leads him to propound opinions of his own and to compare them with suggestions made by Darwin in his account of his cruise in the ship *Beagle*. He places a high estimate on the value of the measurements by the pendulum of Sir Edward Sabine as a means of determining the figure of the earth. From his voyage in 1822 and 1823 much was learned about magnetism in general and terrestrial magnetism in particular. To the establishment of what were deemed by Humboldt sound theories concerning the internal heat of the earth, Fourier, Biot, Laplace and Poisson made large contributions. The mathematical calculations of Friedrich Gauss and Weber were accepted as of the first importance in the study of magnetism. The oscillations of the magnetic needle were observed and noted in different parts of the world. Humboldt himself says in a note, Vol. I., p. 187: "I regard the discovery of the law of the

decrement of magnetic force from the poles to the equator as the most important result of my American voyage." The subject arrested the attention of the British Association, which made special arrangements for its careful study. While living at Quito, Humboldt gave what he deemed first-hand study to the nature and cause of earthquakes and arrived at conclusions which were strengthened, as he believed, by similar studies in the same region by Bousingault, twenty-three years later. Bousingault's treatise on earthquakes, Humboldt accepted as the best and most authoritative ever written. Its theories will hardly be regarded as final by scientists of our time. Rocks, Humboldt declares, without any qualification are in the process of formation and disintegration. He divides them into eruptive, sedimentary, metamorphic and conglomerate rocks. The importance of the subject of paleontology is recognized in "Cosmos," but is treated almost as if it were a new science. Agassiz's work on "Fossil Fishes," in which more than 1,700 species were described, is given the honor it deserves. But open minded as Humboldt was to every suggestion of scientific men and ready to accept any well-authenticated statement, he was very cautious about departures from old and prevailing theories. Since his time, meteorology, as he predicted it would, has become a science of much practical value. Geology, mineralogy and paleontology have made giant strides. Chemistry has almost entirely changed its character, even its terminology has become new. The advance in physics almost defies description. Since Humboldt died Lord Kelvin, Clerk Maxwell of Edinburgh and Herz of Germany have done their epoch-making work on light. Lines of magnetic force and the character of the magnetic field are better understood than when Faraday gave his attention to them and through his discoveries received the warmest praise from Humboldt. Electricity as a science and in its practical applications has developed one might say almost entirely since 1859. Of radium and radio-activity, whose secrets Monsieur and Madame Curie and Rutherford have done so much to make known, Humboldt knew nothing. Nor had he any conception of the character and extent of the revelations from the heavenly bodies which studies in astro-physics have brought. But of science as it was in his day, and for some years after his death, he was a master and as competent as he himself believed and as others admit him to have been to make such general statements concerning its triumphs and promise as to show the careful reader of "Cosmos" even now the foundations upon which the scientific progress of the last half century has rested.

A REVIEW OF THREE FAMOUS ATTACKS UPON THE STUDY OF MATHEMATICS AS A TRAINING OF THE MIND

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NO doubt the most famous attack that has ever been made upon mathematics and its educational value was published in 1836 in the *Edinburgh Review* by Sir William Hamilton, professor of logic and metaphysics at Edinburgh. He must not be confounded with his contemporary, Sir William Rowan Hamilton, the inventor of quaternions. The first reading of that article by the Edinburgh philosopher makes one feel as if in an earthquake in which one's most cherished pedagogic structures are tumbling into a heap and the very foundations are being removed from under one's feet. With the strength of a superhuman giant Hamilton seems to hurl facts with unerring destructive power against the most massive educational castles of his day. The lack of utility of mathematical study, as a training of the mind, is shown by quotations from an array of authorities, gathered from all ages and nations of the civilized world, and the reader is utterly overwhelmed by this "cloud of witnesses."

Upon a second reading of Hamilton's essay one begins to see signs of weakness; an attempt to verify his quotations discloses superficiality and carelessness in the selection of representative quotations from his witnesses. I know of only one mathematician who has made an extended reply to Hamilton, though several have criticized certain parts of his essay. This extended reply is found in an article by A. T. Bledsoe in the *Southern Review* for July, 1877. Bledsoe, a graduate of West Point, was before the civil war professor of mathematics at Kenyon College, then at Miami University, and finally at the University of Virginia. Later he became editor of the *Southern Review*. His reply to Hamilton was printed in the year of his death. It was written after a most careful examination of the authorities cited by Hamilton. It is a very able article, but so far as I have been able to ascertain, it has completely escaped the attention of mathematicians. We can recommend it as interesting and even now worth reading.

A few years ago the noted German mathematician, Alfred Pringsheim, wrote a popular address on the "Utility and Alleged Inutility of Mathematics."[1] Pringsheim, in referring to Hamilton's article,

[1] "Ueber den Wert und angeblichen Unwert der Mathematik," Von Alfred Pringsheim, Muenchen, 1894.

writes down the names of a dozen authorities cited by Hamilton, and then says: "I am ashamed to confess that before reading Hamilton's article I did not know a single one of these great authorities even by name; an extenuating circumstance is the fact that some of these names I could not find even in the scientific directories." However, Hamilton does quote from several noted mathematicians—D'Alembert, Descartes, Pascal, Dugald Stewart—men whose opinions are worthy of serious consideration and study.

Let us now take up Hamilton's essay. It takes the form of a review of William Whewell's "Thoughts on the Study of Mathematics as a Part of a Liberal Education," published in 1835. Whewell was at that time fellow and tutor in Trinity College, Cambridge. Later he became head master of Trinity. At that time the University of Cambridge was laying unusual stress upon mathematics; mathematical skill was the chief requirement in the tripos examinations. Hamilton looked upon the Cambridge plan with disfavor and seized upon Whewell's small pamphlet as a pretext to enter upon a demonstration of the inutility of mathematical study as an exercise of the mind.

In every dispute it is necessary to state the issue clearly and then to adhere to it steadily. The issue is thus stated by Hamilton:[2]

> Before entering on details, it is proper here, once for all, to premise,—in the first place, that the question does not regard the value of mathematical *science*, considered in itself, but the utility of mathematical *study*, as an exercise of the mind; and in the second, that the expediency is not disputed of leaving mathematics, as a coordinate, to find its level among the other branches of academical instruction. It is only contended that they ought not to be made the *principal*, far less the *exclusive* object of encouragement. We speak not of *professional*, but of *liberal* education.

This statement of the issue is quite clear. Moreover, the position taken here is quite fair. Few educators of the present time would take marked exception to it. Mathematics was to occupy a coordinate position in the curriculum with other studies. But Sir William soon forgets his position. He does not adhere to the point of dispute, as laid down by himself, but proceeds to prove that mathematics is "not an improving study." He says:[3]

> If we consult reason, experience and the common testimony of ancient and modern times, none of our intellectual studies tend to cultivate a smaller number of the faculties, in a more partial manner, than mathematics.

He proceeds to adduce testimony to the effect that[4]

> "the cultivation afforded by the mathematics is, in the highest degree, one-sided and contracted," that mathematics "freeze and parch the mind,"[5] that this

[2] *Edinburgh Review*, Vol. 62, 1836, p. 411.
[3] *Loc. cit.*, p. 419.
[4] *Loc. cit.*, p. 421.
[5] *Loc. cit.*, p. 421.
[6] *Loc. cit.*, p. 421.

science is "absolutely pernicious as a mean of internal culture,"[6] that an "excessive" study of the mathematical sciences "absolutely incapacitates the mind, for those intellectual energies which philosophy and life require. We are thus disqualified for *observation either internal or external*—for *abstraction and generalization*—and for *common reasoning;* and disposed to the alternative of blind *credulity* or irrational *scepticism.*"[7] Further on Hamilton says that mathematics can not "conduce to 'logical habits' at all. The art of reasoning *right* is assuredly not to be taught by a process in which there is no reasoning *wrong.*"[8] "But if the study of mathematics do not, as a logical discipline, warn the reason against the fallacies of thought, does it not," inquires Hamilton,[9] "as an invigorating exercise of reason itself, fortify that faculty against their influence?"

To this, Hamilton says, "it is equally incompetent."[10] He next observes "that to minds of any talent, mathematics are *only difficult because they are too easy,*"[11] that "in mathematics dullness is thus elevated into talent, and talent degraded into incapacity."[12] "Of Observation, Experiment, Induction, Analogy, the mathematician knows nothing."[13] "After all," says Hamilton,[14] "we are afraid that D'Alembert is right; mathematics may distort, but can never rectify, the mind."

From these quotations it appears that Hamilton tried to prove that the study of this science is positively injurious to the mind. If this be true, then, of course, mathematics ought to be excluded entirely from a scheme of liberal education, unless, as Bledsoe says,[15] the object of such a scheme be to injure, and not to benefit, the mind of the student. Had Hamilton adhered to the position which he first outlined, he could have entrenched himself behind practically unconquerable breastworks. But what has given notoriety to his paper, is the fact that most of the time he really argues against mathematical study altogether by endeavoring to show that its effect upon the mind is injurious. For seventy-five years Hamilton's article has been singled out as the most powerful argument in existence against mathematics.

To show the alleged pernicious effect of mathematics upon the mind Hamilton's argument proceeds along two principal lines, the first of which is the contention that mathematicians who have confined their studies to mathematics alone are addicted to blind credulity or irrational scepticism and, in general, lack good judgment in affairs of life.

It is my opinion that Hamilton establishes this proposition. The *mere* mathematician is a man of one-sided development. But how about the metaphysician who confines his studies to metaphysics alone?

[7] *Loc. cit.*, p. 424.
[8] *Loc. cit.*, p. 427.
[9] *Loc. cit.*, p. 428.
[10] *Loc. cit.*, p. 428.
[11] *Loc. cit.*, p. 430.
[12] *Loc. cit.*, p. 430.
[13] *Loc. cit.*, p. 433.
[14] *Loc. cit.*, p. 453.
[15] *Southern Review*, Vol. 22, 1877, p. 261.

Is he an all-round man? Is the caveling metaphysician, who disputes all things, very far ahead of the credulous mathematician? Had Hamilton been disposed to attack the study of metaphysics, could he not have made as strong a case against metaphysics as he did make against mathematics? The *mere* metaphysician and the *mere* mathematician are one-sided individuals. How about the *mere* philologist with his roots and stems, the *mere* paleontologist with his old bones, the *mere* physicist with his moment of inertia and latent heat, the *mere* chemist with his pedantic formulæ, the *mere* entomologist with his drawings of beetles? The truth is that the exclusive study of any branch of knowledge is to be discouraged as undesirable for a liberal education. Every one recognizes the dangers of premature and excessive specialization. But because a certain branch of study, taken by itself, fails to accomplish fully all the ends of education, are we to draw the inference that this branch of study is injurious? Because the human body can not readily subsist upon a diet consisting exclusively of roast beef, are we to conclude from this fact alone that roast beef is unhealthy and ought to be banished from the dining table? Yet this is exactly the mode of argument which Hamilton applies to mathematics. Plenty of people are willing to testify that mathematics is not the sole and exclusive intellectual diet that a growing boy should have. From testimony of this sort Hamilton attempts to argue that "mathematics may distort, but can never rectify, the mind."[16] In our humble opinion the learned philosopher is guilty of a very unphilosophical argument, "unphilosophical in its design, in its spirit, and in its execution."[17]

We said that Hamilton argues along two principal lines. His second mode of attack is to show that many mathematicians, some of them of great eminence, have found mathematics unsatisfactory as an exercise of the mind, and have renounced it. I hardly know how to approach this part of Hamilton's argument. For lack of space I can not demonstrate the conclusions we are about to state. Bledsoe's reply to Hamilton covers sixty-nine pages, and for details we must refer you to him and to the authorities quoted by Bledsoe and Hamilton. By his extensive inquiry Bledsoe proves what some other writers before him hinted at, or proved only in part, namely, that Hamilton was extremely careless in the selection of his quotations. By means of partial extracts, badly chosen, he made scientists say exactly the opposite of their real sentiments. Bledsoe convicts Hamilton of this practise in his quotations from D'Alembert, Pascal, Descartes and Dugald Stewart, who are the most celebrated mathematical witnesses called by Hamilton.

Take the case of Descartes. We quote from Hamilton the following:[18]

[16] *Loc. cit.*, p. 453.
[17] *Southern Review*, Vol. 22, p. 282.
[18] *Loc. cit.*, p. 421.

Nay, Descartes, the greatest mathematician of his age, and in spite of his mathematics, also its greatest philosopher, was convinced from his own consciousness, that these sciences, however valuable as an instrument of external science, are absolutely pernicious as a mean of internal culture. "It was now a long time" (says Baillet, his biographer under the year 1623, the 28th of the philosopher) "since he had been convinced of the small utility of the mathematics, especially when studied on their own account, and not applied to other things. There was nothing, in fact, which appeared to him more futile than to occupy ourselves with simple numbers and imaginary figures, as if it were proper to confine ourselves to these trifles (bagatelles) without carrying our view beyond. There even seemed to him in this something worse than useless. His maxim was, that such application insensibly disaccustomed us to the use of our reason, and made us run the danger of losing the path which it traces." ("Cartesii Lib. de Directione Ingenii," Regula 4, MS.) "In a letter to Mersenne, written 1630, M. DesCartes recalled to him that he had renounced the study of mathematics for many years; and that he was anxious not to lose any more of his time in the barren operations of geometry and arithmetic, studies which never lead to anything important." Speaking of the general character of the philosopher, Baillet adds, "In regard to the rest of mathematics [he had just spoken of astronomy, which Descartes thought, 'though he dreamt in it himself, only a loss of time'], those who know the rank which he held above all mathematicians, ancient and modern, will agree that he was the man in the world best qualified to judge them. We have observed that, after having studied them to the bottom, he had renounced those of no use for the conduct of life, and the solace of mankind."[19]

"The study of mathematics" (says Descartes, and he frequently repeats the observation) "principally exercises the imagination in the consideration of figures and motions."[20] Nay, on this very ground, he explains the incapacity of mathematicians for philosophy. "That part of the mind," says he, in a letter to Father Mersenne, "viz., the imagination, which is principally conducive to a skill in mathematics, is of greater detriment than service for metaphysical speculations."[21]

These are Hamilton's references to Descartes which contain quotations from Descartes or his biographer Baillet. Evidently Hamilton was guided more by what Baillet stated about Descartes than upon what Descartes himself actually said. The letters to Mersenne simply show that Descartes was not inclined to confine his activities to mathematics, nor ready to admit that mathematical training alone constituted adequate preparation for the study of philosophy. In quoting from Descartes's "Rule Four" for conducting philosophical inquiries, Bledsoe puts into italics the passage garbled by Hamilton and Baillet. It can thus be easily read in connection with what immediately precedes and follows, and one can readily see how Hamilton's extract, by itself, conveys an impression quite the opposite of that conveyed by the entire passage. Descartes gives an exposition of his method of philosophical inquiry. He says that he wishes to apply his method not merely to the ancient "arithmetic and geometry," but to other sciences

[19] "La Vie de Descartes," P. I., pp. 111, 112, 225; P. II., p. 481.

[20] "Lettres," P. I., let. xxx.

[21] *Loc. cit.*, p. 426.

where progress has been hitherto arrested. To apply it to arithmetic and geometry alone would be to occupy himself with "trifles," not only because of the narrow field of application, but also because what was practically his method had been thus applied long ago by the Greeks. He wished to direct his method to unsolved problems. But he is free to acknowledge that his method is found in mathematics as in an envelop. "Now I say that the mathematics are the envelope of this method, not that I wish to conceal and envelop it, in order to keep the vulgar away from it; on the contrary, I wish to dress and adorn it, in such manner that it may be more easily grasped by the mind."[22]

In all this there is no attack whatever upon the culture value of mathematics. Instead of hostility he shows friendliness to mathematics as a gymnast of the mind. In his discussion of the "Fourth Rule" there is a passage, not quoted by Hamilton, which bears directly upon the question at issue: "This is why I have cultivated even to this day, as much as I have been able, that universal mathematical science, so that I believe I may hereafter devote myself to other sciences, without fearing that my efforts may be premature."[23] Here then Descartes declares that, as much as possible, he had studied mathematics all his life, as a preparation or propædeutic to philosophy. It appears that Descartes looked upon mathematical study as a desirable preparation to philosophy, just as Plato had done nearly 2,000 years earlier. Looking at the testimony contained in Descartes's writings, as a whole, there is nothing in it to disturb in the least the belief in the educational value of mathematical study.

As a side issue we touch upon Hamilton's assertion that Descartes in 1623 renounced mathematics for good. Hamilton does not say that the work which is memorable in the history of mathematics as the creation of analytical geometry was published by Descartes 14 years later, in 1637. Did Descartes renounce mathematics for good? The life of Descartes which was prepared by M. Thomas, a biography which captured the prize offered by the French Academy in 1765, a biography which is placed first in Cousin's edition of the works of Descartes, says this about Descartes's renunciation (p. 89): "He attempted at least five or six times to renounce them, but he always returned to them again." M. Thomas adds: "He wished to occupy himself henceforth only with morals; but on the first occasion he returned to the study of nature. Borne away in spite of himself, he plunged anew into the abstract sciences" (p. 92).

I proceed now to a review of a second attack upon mathematical study, made by Schopenhauer, the pessimistic sage of Frankfort-on-the-Main. His thoughts on mathematics are expressed in his work, entitled, "The World as Will and Idea," as it appeared in its second edi-

[22] *Southern Review*, Vol. 22, p. 270.
[23] *Southern Review*, Vol. 22, p. 271.

tion, 1844. Schopenhauer's views must have attracted considerable attention in Germany, for as late as 1894 Alfred Pringsheim thought it necessary to refute his argument, and only four years ago Felix Klein referred to him at some length in a mathematical lecture at the University of Goettingen. Schopenhauer had read Sir William Hamilton, as appears from the following passage:[24]

I rather recommend, as an investigation of the influence of mathematics upon our mental powers, . . . a very thorough and learned discussion, in the form of a review of a book by Whewell in the *Edinburgh Review* of January, 1836. Its author, who afterwards published it with some other discussions, with his name, is Sir W. Hamilton, Professor of Logic and Metaphysics in Scotland. This work has also found a German translator, and has appeared by itself under the title, "Ueber den Werth und Unwerth der Mathematik, aus dem Englischen," 1836. The conclusion the author arrives at is that the value of mathematics is only indirect, and lies in the application to ends which are only attainable through them; but in themselves mathematics leave the mind where they find it, and are by no means conducive to its general culture and development, nay, even a decided hindrance. This conclusion is not only proved by thorough dianoiological investigation of the mathematical activity of the mind, but is also confirmed by a very learned accumulation of examples and authorities. The only direct use which is left to mathematics is that it can accustom restless and unsteady minds to fix their attention. Even Descartes, who was yet himself famous as a mathematician, held the same opinion with regard to mathematics.

These words of Schopenhauer are an unqualified endorsement of Hamilton, the only such endorsement with which I happen to be familiar.

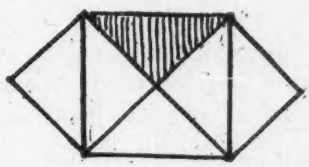
Schopenhauer's own argument is mainly directed against Euclid and his geometrical demonstrations. Schopenhauer had his own ideas as to how absolute truth can be reached; these ideas did not agree with the method of Euclid. Our German philosopher says:[25]

If now our conviction that perception is the primary source of all evidence, and that only direct or indirect connection with it is absolute truth; and further, that the shortest way to this is always the surest, as every interposition of concepts means exposure to many deceptions; if, I say, we now turn with this conviction to mathematics, as it was established as a science by Euclid, and has remained as a whole to our own day, we can not help regarding the method it adopts as strange and indeed perverted. We ask that every logical proof shall be traced back to an origin in perception; but mathematics, on the contrary, is at great pains deliberately to throw away the evidence of perception which is peculiar to it, and always at hand, that it may substitute for it logical demonstration. This must seem to us like the action of a man who cuts off his legs in order to go on crutches . . . (page 92). We are compelled by the principle of contradiction to admit that what Euclid demonstrates is true, but we do not comprehend *why* it is so. We have therefore almost the same uncomfortable feeling that we experience after a juggling trick, and, in fact, most of Euclid's demonstrations are remarkably like such feats. The truth almost always enters by the back door, for it manifests itself *par accidens* through some contingent circumstance.

[24] A. Schopenhauer, "The World as Will and Idea," translated by R. B. Haldane and J. Kemp, Vol. II., London, 1891, p. 323.

[25] *Loc. cit.*, Vol. I., 1891, par. 15, p. 90.

Often a *reductio ad absurdum* shuts all the doors one after another, until only one is left through which we are therefore compelled to enter. Often, as in the proposition of Pythagoras, lines are drawn, we don't know why, and it afterwards appears that they were traps which close unexpectedly and take prisoner the assent of the astonished learner . . . (page 94). Euclid's logical method of treating mathematics is a useless precaution, a crutch for sound legs . . . (page 95). The proposition of Pythagoras teaches us a *qualitas occulta* of the right-angled triangle; the stilted and indeed fallacious demonstration of Euclid forsakes us at the *why*, and a simple figure, which we already know, and which is present to us, gives at a glance far more insight into the matter, and firm inner conviction of that necessity, and of the dependence of that quality upon the right triangle:



In the case of unequal catheti also, and indeed generally in the case of every possible geometrical truth, it is quite possible to obtain such a conviction based on perception . . . (page 96). It is the analytical method in general that I wish for the exposition of mathematics, instead of the synthetical method which Euclid made use of.

In the above we have Schopenhauer's famous characterization of mathematical reasoning as "mouse-trap proofs" (Mausefallenbeweise). These quotations and other passages which space does not permit us to quote indicate that his objections are directed almost entirely against Euclid. Schopenhauer discloses no acquaintance with such modern mathematical concepts as that of a function, of a variable, of coordinate representation, and the use of graphic methods. With him Euclid and mathematics are largely synonymous. Because of this one-sided and limited vision we can hardly look upon Schopenhauer as a competent judge of the educational value of modern mathematics.

If Schopenhauer's criticism of Euclid is taken as the expression of the feelings, not of an advanced mathematician, but of a person first entering upon the study of geometry and using Euclid's "Elements," then we are willing to admit the validity of Schopenhauer's criticisms, in part. Euclid did not write his geometry for children. It is a historical puzzle, difficult to explain, how Euclid ever came to be regarded as a text suitable for the first introduction into geometry. Euclid is written for trained minds, not for immature children. Of interest is Schopenhauer's reference to the method of proof, called the *reductio ad absurdum*. The experience of teachers with this method has been much the same in all countries. Some French critics called it a method which "convinces but does not satisfy the mind." De Morgan says: "The most serious embarrassment in the purely reasoning part is the *reductio ad absurdum*, or indirect demonstration. This form of argument is generally the last to be clearly understood, though it occurs almost on the threshold of the 'Elements.' We may find the key to the difficulty in the confined ideas which prevail on the modes of speech there employed."

On the main idea of what mathematical proof should be, the mathematician can hardly agree with Schopenhauer. Schopenhauer considers a succession of separate logical conclusions, which are contained in a rigorous mathematical proof, as insufficient and unendurable; he wants to be convinced of the truth of a theorem instantaneously, by an act of *intuition*. He advances the theory that, besides the severely logical deductions there is another method of proving mathematical truths, that of direct perception and intuition. We agree with Schopenhauer that intuition should play an important part, especially in preliminary courses, before children enter upon courses in demonstrative geometry; but eventually the logical proof must be made to follow before we are prepared to accept a proposition as established. Schopenhauer directs his criticisms particularly against Euclid's proof of the Pythagorean Theorem and then offers his own proof, which is practically the same as the Hindu proof and can be given by drawing the figure and then explaining, as did the Hindus, "Behold." But Schopenhauer's is not a *general* proof; it holds only for a special case, namely, for the isosceles right triangle.

Really, Euclid's proof of the Pythagorean Theorem consists of a number of steps, each of which is quite evident to the eye. Thus a square is represented as the sum of two rectangles, which is an intuitive relation. Then each rectangle is shown to be equal to double a triangle of the same base and altitude. This again the child accepts the more readily as more or less intuitively evident. And so on. Every step appears quite reasonable to one depending on intuition alone. It does seem as if Schopenhauer could have made a better selection from Euclid for his point of attack.

From what we have said it appears that Schopenhauer's attack bears only indirectly upon the question relating to the mind-training value of mathematics; his criticism is focused directly upon questions of logic, of mode of argumentation and of sufficiency of proof.

I pass now to a third attack upon mathematics, made in 1869 by the naturalist, Thomas H. Huxley. So far as I know, Huxley was not influenced either by Hamilton or Schopenhauer, though the words he used remind us of a sentence in Hamilton. Hamilton had said: "Of Observation, Experiment, Induction, Analogy, the mathematician knows nothing."[26] Huxley, in the June number of the *Fortnightly Review*, 1869, said: Mathematics is that study "which knows nothing of observation, nothing of experiment, nothing of induction, nothing of causation."[27] Huxley and Hamilton both name observation, experiment, induction, but they differ in the fourth process. Hamilton says "analogy"; Huxley says "causation."

In the same year there appeared in print an after-dinner speech de-

[26] *Edinburgh Review*, Vol. 22, p. 433.

[27] *Fortnightly Review*, London, Vol. 5, 1869, p. 667.

livered by Huxley before the Liverpool Philomathic Society[28] in which he argued in favor of scientific education, as follows:

> The great peculiarity of scientific training, that in virtue of which it can not be replaced by any other discipline whatsoever, is the bringing of the mind directly into contact with fact, and practising the intellect in the completed form of induction; that is to say, in drawing conclusions from particular facts made known by immediate observation of nature.
>
> The other studies which enter into ordinary education do not discipline the mind in this way. Mathematical training is almost purely deductive. The mathematician starts with a few simple propositions, the proof of which is so obvious that they are called self-evident, and the rest of his work consists of subtle deductions from them. The teaching of languages, at any rate as ordinarily practised, is of the same general nature—authority and tradition furnish the data, and the mental operations of the scholar are deductive.

It will be noticed that these remarks were made at a time when there was a conflict on the question of educational values between the classics and mathematics, on one side, and the natural and social sciences, on the other. This makes it evident that Huxley appeared in this discussion in the capacity of an advocate rather than as a judge.

Of great interest, in connection with Huxley's utterances is the reply made to him by the mathematician J. J. Sylvester. To Americans Sylvester's name is memorable, because at one time he was on the faculty of the University of Virginia and, when the Johns Hopkins University opened in 1876, Sylvester again came over from England and for eight years lectured to American students on modern higher algebra. He gave a powerful stimulus to the study of higher mathematics in this country. Sylvester was an enthusiast. His reply to Huxley was the subject of his presidential address to the mathematical and physical section of the British Association, meeting at Exeter in 1869. This address is of special value, because it is largely autobiographical; it tells how Sylvester carried on his researches in mathematics, how he came to make some of his discoveries. By his own experiences as a mathematical investigator he tried to show that Huxley's description of mathematical activity was incorrect. We can do no better than quote rather freely from Sylvester's memorable address. He says:

> I set to myself the task of considering certain recent utterances of a most distinguished member of this Association, one whom I no less respect for his honesty and public spirit than I admire for his genius and eloquence, but from whose opinions on a subject which he has not studied I feel constrained to differ. Göthe has said:
>
> "Verständige Leute kannst du irren sehn:
> In Sachen, nämlich, die sie nicht verstehn."
> "Understanding people you may see erring
> In those things, to wit, which they do not understand. . . ."
>
> He [Huxley] says "mathematical training is almost purely deductive. The mathematician starts with a few simple propositions, the proof of which is so

[28] *Macmillan's Magazine*, Vol. 20, London, 1869, pp. 177–184.

obvious that they are called self-evident, and the rest of his work consists of subtle deductions from them. The teaching of languages, at any rate as ordinarily practised, is of the same general nature—authority and tradition furnish the data, and the mental operations are deductive." It would seem that from the above somewhat singularly juxtaposed paragraphs that, according to Professor Huxley, the business of a mathematical student is from a limited number of propositions (bottled up and labelled ready for future use) to deduce any required result by a process of the same general nature as a student of language employs in declining and conjugating his nouns and verbs—that to make out a mathematical proposition and to construe or parse a sentence are equivalent or identical mental operations. Such an opinion scarcely seems to need serious refutation.

Further on Sylvester says:

We are told that "mathematics is that study which knows nothing of observation, nothing of experiment, nothing of induction, nothing of causation." I think no statement could have been more opposite to the undoubted facts of the case; that mathematical analysis is constantly invoking the aid of new principles, new ideas and new methods, not capable of being defined by any form of words, but springing direct from the inherent powers and activity of the human mind, and from continually renewed introspection of that inner world of thought of which the phenomena are as varied and require as close attention to discern as those of the outer physical world, . . . that it is unceasingly calling forth the faculties of observation and comparison, that one of its principal weapons is induction, that it has frequent recourse to experimental trial and verification, and that it affords a boundless scope for the exercise of the highest efforts of imagination and invention.

Lagrange . . . has expressed emphatically his belief in the importance to the mathematician of the faculty of observation; Gauss has called mathematics a science of the eye . . .; the ever to be lamented Riemann has written a thesis to show that the basis of our conception of space is purely empirical, and our knowledge of its laws the result of observation, that other kinds of space might be conceived to exist subject to laws different from those which govern the actual space in which we are immersed. . . . Most, if not all, of the great ideas of modern mathematics have had their origin in observation. Take, for instance, . . . Sturm's theorem about the roots of equations, which, as he informed me with his own lips, stared him in the face in the midst of some mechanical investigations connected with the motion of compound pendulums.

After citing many other instances, Sylvester says:

I might go on, were it necessary, piling instance upon instance, to prove the paramount importance of the faculty of observation to the progress of mathematical discovery. Were it not unbecoming to dilate on one's personal experience, I could tell a story of almost romantic interest about my own latest researches in a field where Geometry, Algebra, and the Theory of Numbers melt in a surprising manner into one another, . . . which would very strikingly illustrate how much observation, divination, induction, experimental trial, and verification, causation, too (if that means, as I suppose it must, mounting from phenomena to their reasons or causes of being), have to do with the work of the mathematician. In the face of these facts, which every analyst in this room or out of it can vouch for out of his own knowledge and personal experience, how can it be maintained, in the words of Professor Huxley, who, in this instance, is speaking of the sciences as they are in themselves and without any reference to scholastic discipline, that Mathematics "is that study which knows

nothing of observation, nothing of induction, nothing of experiment, nothing of causation.''

I, of course, am not so absurd as to maintain that the habit of observation of external nature will be best or in any degree cultivated by the study of mathematics, at all events as that study is at present conducted, and no one can desire more earnestly than myself to see natural and experimental science introduced into our schools as a primary and indispensable branch of education: I think that that study and mathematical culture should go on hand in hand together, and that they would greatly influence each other for their mutual good. I would rejoice to see mathematics taught with that life and animation which the presence and example of her young and buoyant sister could not fail to impart, short roads preferred to long ones, Euclid honourably shelved or buried ''deeper than e'er plummet sounded'' out of the schoolboy's reach, morphology introduced into the elements of Algebra—projection, correlation, and motion accepted as aids to geometry—the mind of the student quickened and elevated and his faith awakened by early initiation into the ruling ideas of polarity, continuity, infinity, and familiarization with the doctrine of the imaginary and inconceivable.

What light, if any, do these attacks and these defenses of mathematical study throw upon the educational problems of to-day? Hamilton gathered a cloud of witnesses which, in so far as the testimony adduced was sincere, proved that mathematical study alone is not the proper education for life. That mathematical study is pernicious Hamilton did not succeed in proving. It would seem, therefore, as if the Hamiltonian controversy was somewhat barren in useful results. Probably no one to-day advocates the well-nigh exclusive study of mathematics or of any other science as the best education obtainable.

Schopenhauer attacked mainly the logic of mathematics as found in Euclid. As a critique of the logic as used by Euclid the attack is childish and has no value for us. From the standpoint of educational method it points out the difficulty experienced by children in understanding the mode of proof called the *reductio ad absurdum* and emphasizes the constant need of appeal to the intuition in the teaching of mathematics.

The attack made by Huxley touches questions which are more subtle. Sylvester, in his rejoinder, proved conclusively that the mathematician engaged in original research does exercise powers of internal observation, of induction, of experimentation and even of causation. Are these powers exercised by the pupil in the class room? That depends. When English teachers required several books of Euclid to be memorized, even including the lettering of figures, no original exercises being demanded, then indeed such teaching knew nothing of observation, induction, experiment, and causation, except that a good memory as a cause was seen to bring about a pass mark as an effect. But when attention is paid to the solution of original exercises, and to the heuristic or genetic development of certain parts of the subject, then surely the young pupil

exercises the same faculties as does the advanced mathematician engaged in research.

The language used by Huxley and Sylvester is not in accord with some of the ideas of recent American psychologists, who declare that teachers should not attempt to train particular mental faculties. We have seen that Hamilton, Huxley and Sylvester discussed the training of the faculty of "observation," the "reasoning faculty" or the "power of observation." Hamilton complains that "none of our intellectual studies tend to cultivate a smaller number of the faculties, in a more partial manner, than mathematics."[29] Recent writers object to this point of view. The teacher must "stop wet-nursing orphan mental faculties"; his business is "to select points of contact between learning minds and the reality that is to be learned." The recent movement is a remarkable reaction against the time-honored "doctrine of formal discipline," which originated with the Greeks and probably reached its height in the time of Huxley. In its extreme form this is "the doctrine of the applicability of mental power, however gained, to any department of human activity."[30] In its place comes the doctrine of "specific disciplines," according to which "improvement of any one mental function or activity will improve others only in so far as they possess elements common to it also." The subject is still in the polemical stage. The new psychology is not hostile to mathematics, except perhaps to the formal or mechanical parts of algebra. A point which may harmonize in part the old and the new views, and which in itself demands very lively consideration, lies in the claim put forth recently, that the benefit to be derived from a subject like mathematics depends largely upon the attitude toward it maintained by the teacher and pupil. They should be controlled by ideals to be reached as a goal, such as ideals of accuracy, of efficiency, of scientific method. "If we have trained pupils to think rigidly in geometry, for example, how shall we insure an application of rigid thinking to situations that lack the geometrical elements? . . . Shall we not have the greatest assurance of such transfer, if the method has been made to appeal to the pupil as something thoroughly worth while?"[31] No doubt this feature has figured prominently in the mathematical teaching of all ages, but recent is the psychological recognition of it as a conscious factor in the transfer of special training to new fields of action.

[29] *Edinburgh Review*, Vol. 22, p. 419.

[30] W. H. Heck, "Mental Discipline and Educational Values," New York, 1909, p. 7 and other places.

[31] W. C. Bagley, "Educational Values," New York, 1911, p. 194.

THE RED SUNFLOWER

By Professor T. D. A. COCKERELL
UNIVERSITY OF COLORADO

ONCE upon a time, in England, a certain bishop visited a Sunday-school. Being asked to question the children, he inquired of a small and timid boy, "Who made the world?" Completely rattled, the child made no answer. The bishop asked a second time, and, again getting no result, exclaimed in some wrath, "Is it possible, my dear boy, that you don't know who made the world?" The youngster burst into tears, and declared earnestly, "Please, sir, I didn't do it, indeed I didn't do it!"

I have found this story useful in the discussions on the genesis of the red sunflower. The first question people ask is even more direct than that of the bishop, "How did you do it?" The answer is, "We did not do it, but—the author of the world is also the author of the red sunflower."

My wife and I have lived in New Mexico and Colorado for many years, and have seen, I suppose, millions of sunflowers. So far as we know, we had never seen a red one until 1910, nor had any one else, excepting some horticultural forms of a kind quite different from the ordinary plant. The summer before last, in Boulder, Colorado, there was a group of sunflowers growing by the road about a hundred yards from our house. Having occasion to cross the road, my wife noticed what she supposed to be a large butterfly, presumably one of the silver-spots, on a sunflower head. Glancing at the plant a little later, she was surprised to note that the butterfly had not moved, and approaching nearer to satisfy her curiosity, found the red sunflower. There was no butterfly; the red appearance was due to the rays, which were deeply suffused with a fine chestnut red. There was only one plant, and this close to the road, where hundreds of people passed daily. Already some one had picked a head as a curiosity. Evidently it was not safe to leave the plant where it was; it would almost surely be destroyed. We had had no experience in transplanting sunflowers, especially in full bloom, so we tried first with one of the common kind. Succeeding well, we carefully dug up the red one, and removed it to our garden. Here, on bended knees, it was carefully tended, and a contrivance was arranged to protect it at first from the direct rays of the sun. It soon recovered from the shock, and proceeded to bloom and go to seed in a normal way.

So far good: but now a difficulty arose. On looking up the literature, we found that Dr. G. H. Shull had experimented with sunflowers, and had found them invariably self-sterile. That is to say, no sunflower would produce seed with its own pollen, even though it came from a different head. Here was a dilemma; there was, so far as we could tell, only one plant of the red sunflower in the world, and this could not be self-fertilized! The only thing to do was to make crosses with ordinary sunflowers, and see what would come of it. It must now be explained that, aside from the color of the rays, there are many kinds of sunflowers. Putting aside the perennial species and annuals like the small "cucumber-leafed" *Helianthus debilis,* there are several types closely related to the "common or garden" sunflower, *Helianthus annuus.* All are called *Helianthus,* which is simply Greek for sunflower. The red sunflower found at Boulder belongs to the prairie species, called by some botanists *Helianthus lenticularis,* by others simply a variety of *Helianthus annuus.* It is perfectly fertile with the garden strains of *annuus,* but has a number of marked characteristics. Less robust than the cultivated forms, it branches very freely and produces numerous relatively small heads of flowers. The center, or disc, which is yellow in the big "Russian" sunflower, is "black," or strictly speaking a dark purplish-red.

The red sunflower was crossed with the Russian, the wild *lenticularis,* and with a plant which we took to be a cross, Russian and *lenticularis.* All the crosses were made by Mrs. Cockerell, who has in fact done all the work on the red sunflower. The accompanying illustration shows some of the heads covered with bags to protect them from the bees and birds and save the seeds. Crosses could be made either way, that is, using "red" pollen on the other sorts, or other pollen on the red. It was necessary in each case to "bag" the head before it came into flower, and to watch very carefully whenever the bags were off for pollination or inspection. The bees are tireless in visiting sunflowers, and scarcely a moment seems to pass during the warm part of the day when an unprotected head is not visited. A single bee might easily spoil an experiment by bringing unaccounted-for pollen, while later small finches were present in flocks to eat the seeds. All this work was time-consuming and laborious, but there is no other way if exact results are desired. Taking the principal characters, as cited above, we may tabulate the two main crosses as follows. The name *coronatus,* now used for the red sunflower, was proposed in *Science,* 1910, and was suggested by a certain resemblance to the sun in eclipse, showing the corona. The sign × signifies a cross.

(1) Coronatus × Lenticularis	
Red rays	× yellow rays
Dark disc	× dark disc

Branched habit × branched habit
Small heads × small heads
(2) CORONATUS × ANNUUS ("Russian")
Red rays × yellow rays
Dark disc × yellow disc
Branched habit × unbranched habit
Small heads × large heads.

We later found a plant of *lenticularis* showing a little red on the rays, and of course used this in a cross.

Could we predict the result of these crosses? Yes, to some extent. Could we regain the red as it was before the cross? Yes, no doubt, but in order to explain how, it is necessary to digress.

During the sixties, Gregor Mendel, Prälat at Brünn in Moravia, experimented with plants, especially garden peas. He was the first to appreciate the necessity of following up crosses for several successive generations, tabulating the results in each case, and ascertaining the numerical proportions of the differing forms resulting. He also took pains to consider the different sets of characters separately, treating them statistically as if they were different organisms. Working in this way, Mendel discovered that when two varieties are crossed the resulting hybrid is frequently not intermediate, but resembles one or the other parent. In other cases, when the hybrid, as a whole, seems intermediate, the several *characters* are nevertheless found to correspond with those of one or the other parent. When this sort of thing occurs, the character which comes uppermost in the cross is said to be *dominant,* the one which remains latent or hidden is called *recessive.*[1] Inasmuch as fertilization results from the fusion of the germ-cells of the two parents, it is evident that each individual hybrid must contain material derived from both, although only the characters of one parent may be visible. Now Mendel found that when hybrids obtained as described were crossed together in the next generation he got, in simple cases, three of the "dominant" type to one of the "recessive." Of course the proportions would not be always thus, but whenever the number of cases was large they approximated so closely to the three-to-one ratio, that he became convinced that this was no accident. A simple theory was formulated, according to which the results arose from the chance combination of the elements in the germ cells. We may now make this clearer by a diagram in which D stands for the character which is dominant, R for that which is recessive.

First cross, DD × RR

[1] The matter is complicated by the fact that the "recessive" condition may result from the simple absence of the dominant factor; or one factor, when present, may inhibit or else hide a second. For the latter class of cases the terms epistatic and hypostatic have been proposed by Bateson.

This is written DD and RR, not simply D and R, because we are supposing that each individual is pure for the character involved, that is, has received D or R from each parent.

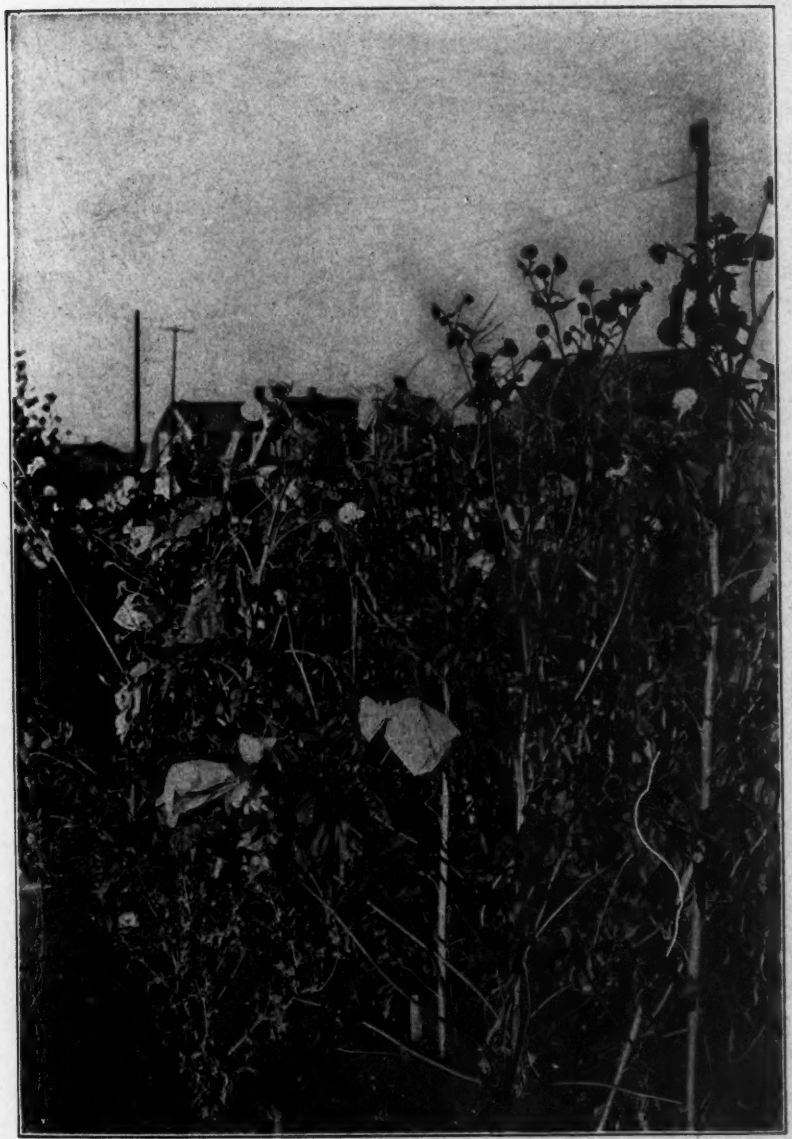
First filial generation DR × DR × DR × DR, as many as there may happen to be. These are written DR because each gets D from one parent (which has nothing else to give) and of course R from the other. Now in the next generation each parent contributes, not its whole "DR," but one or the other, according to the laws of chance. Accordingly, DR × DR may produce a DD, or a DR, or a RR, and as a matter of fact, they do so. Why should there be any particular numerical proportion? If we put black and white balls in a bag, and draw them out in pairs at random, the chances are equal that we shall get two alike, or two different. It is so with our crosses. The cases in which we get two alike may be of two kinds, both black or both white, or in the case of the crosses, both D or both R. The cases in which we get two different are necessarily alike, black and white, or D with R. Hence, according to the law of chance, we expect in the third generation the following:

1. Both alike, DD and RR.
2. Not alike, DR and RD, which are the same.

Now we have seen that because of dominance R does not show when D is present, so that a DR looks like a DD. Consequently, of the above four cases, *three* show the dominant character, and *one* (RR) shows the recessive. The whole diagram may now be reconstructed:

1. DD × RR (original cross).
2. DR × DR × DR × DR (first filial generation).
3. DD × DR × RD × RR (second filial generation, or grandchildren). How can this be confirmed? Obviously, if the facts are as here given, the DD and the RR of the third line are now *pure,* in spite of the fact that the DD had an RR grandparent and a DR parent, and the RR a similarly complicated ancestry. Take a number of these pure types, now called "extracted recessives" and "extracted dominants," and breed them separately, the DDs with DDs, and the RRs with RRs, and they *will breed true,* and their descendents will forever remain true, unless contaminated by a cross, or some new variation arises. The DRs, however, when bred together, will again produce the "three-to-one" results, just like their parents. Consequently, it is possible to extract a pure strain out of an impure one, a fact of tremendous scientific and practical importance.

Mendel's results were published in Brünn in 1866, but attracted little or no attention. They never became known to Darwin, who would have immediately perceived their importance. In 1884, when Mendel died, no one had the slightest idea that his name would ever be familiar to scientific workers, though Mendel himself used to say "Meine Zeit



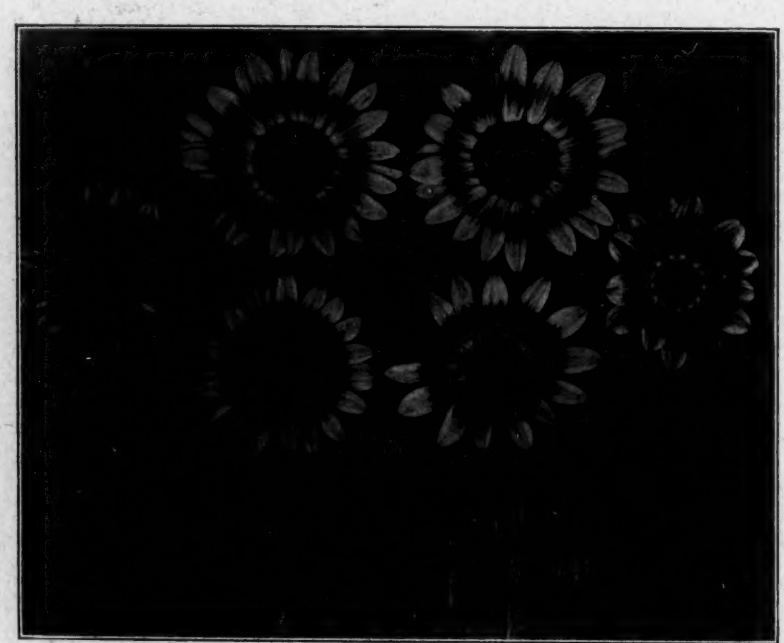
SUNFLOWER GARDEN SHOWING HEADS WITH BAGS.

wird schon kommen!" In 1900 three European workers almost simultaneously discovered Mendel's paper, and to-day "Mendelism" is talked of everywhere, and books are written upon it.

Mendel himself could hardly have foreseen the wide application of his theory. It has been applied to animals and plants with like success, and scarcely a month passes without the publication of new "Mendelian results." In practical breeding, it has opened up a new era, and

it would be difficult to overestimate the importance of the results certain to be obtained within the next fifty years. It has even been found that Mendel's discovery lights up the way toward the improvement of the human race, and it may well be that many of us now living will see the day when Mendelian questions will enter the field of practical politics.

As experimental work progressed, it was found that many complications arose, so that it was often difficult to interpret the results. Without going into these matters in detail, we must note that frequently the first cross "DR" is not like either parent, that is to say, dominance is not complete. Indeed, experienced breeders say that they can



RED SUNFLOWER.

nearly always tell an impure form from a pure individual, although at first sight they may look alike. Critics of Mendelism were at first inclined to think that the failure of strict "dominance" invalidated the theory, but this is by no means the case, as the elements separate out in the third generation, just as before. The only difference is that as one can tell the DD from the DR, in the third generation we have *three* visible types instead of two, in the proportions 1, 1, 2.

Now to return to the sunflower; the first thing we were anxious to know was, will the red be dominant? From analogy with other cases, we thought it would. Being impatient, we obtained permission from our friend Mr. Knudsen to grow a few plants during the winter of

1910–11 in his greenhouse. They grew to enormous size (being the Russian × *coronatus* cross), but when at length they flowered, *all the rays were pure yellow!* This was indeed disappointing, though we thought we could readily get the red back in the next generation. In the meanwhile, the greater part of the seed was sown in our garden, though some was sent to the English naturalist Dr. A. R. Wallace, who successfully raised the plants. During the summer we went east, but before we left, we noted with hope that some of the young plants showed a great deal of purple in the stems. On our return early in August, a gorgeous sight met our eyes. The sunflowers were in full bloom, and about half were splendidly red! The reds were by no means uniform, as the accompanying figure shows, some having a ring of red, while others were suffused with red all over, and others showed only a little of the color. Indeed on a single plant there is great variation, and often heads on a genuinely "red" plant may have wholly yellow rays. This results from the fact that the red is produced as the end-result of a chemical process, which seems to be completed only under favorable conditions. Thus a "yellow" head on a red plant differs fundamentally from a true yellow in its make-up, but resembles it, owing to what may be called a lack of opportunity. The controlling factors are not well understood, but even in the case of the original plant, the last small heads of the season were almost entirely yellow-rayed.

I have said that about half of our sunflowers were of the red type. It was a matter of chance that the four grown in the greenhouse were all yellow. But how can we reconcile these results with Mendel's law? *All* were crossed with red: if red is dominant, then *all* should be red; if it is recessive, *none* should. The explanation is, no doubt, that the original plant was a DR, not a DD. This could come about without the existence of earlier red plants, by a variation occurring in a germ-cell, which mated, of course, with one which was normal. Consequently, the original plant, though it may have had no red parent, was in fact a hybrid (or more correctly, mongrel), and *we have not yet seen a "pure" red.*

The accompanying diagram represents the supposed course of events. The first line (1910) shows the original cross made by us. When YY meets RY, two combinations are possible, and are equally probable, namely, YY (yellow) and RY (red). The result observed in 1911 thus follows naturally. The third line shows what may be obtained in 1912. If the yellows are mated, we get only yellows. We have a few of these already in bud, from seed gathered from the greenhouse plants. If we cross the reds with reds (as has been done in large numbers) we must expect one fourth pure yellows, one half impure reds like the parents (I have drawn only one to save space), and one fourth "pure" reds.

I have drawn the "pure" red very dark, on the supposition that it will be visibly more highly colored than anything yet seen, although this may not prove to be the case. If it is distinguishable, we shall then permanently isolate the red without further trouble; if it is no different from the impure reds, it will only be possible to separate the pure strain by noting the results of numerous crosses made at random.

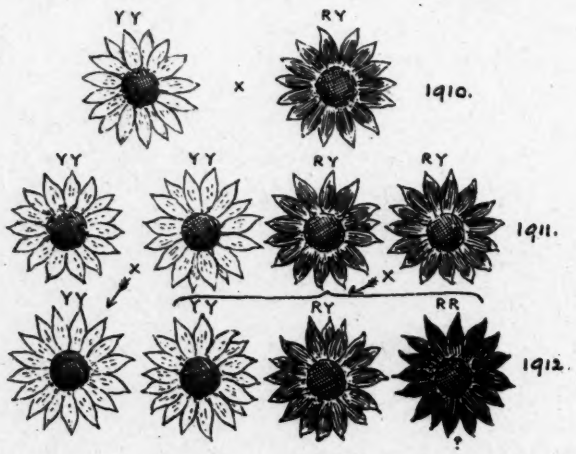


DIAGRAM SHOWING THE FIRST CROSS MADE WITH THE RED SUNFLOWER, the result obtained in 1911 and the expected result for 1912. *Y* = yellow-ray factor; *R* = red-ray factor.

Last year we made various new crosses, especially with the great double "chrysanthemum-flowered" variety obtained from Dreer of Philadelphia. If we can get this red, as we doubtless can, it will be a striking plant, though perhaps less attractive than the single kinds. In tabulating the characters crossed, I enumerated not only the ray color, but also the color of the disc, the size of the heads, and the manner of growth. In the *coronatus* × *lenticularis* cross, everything except ray color is the same on both sides, so there is nothing to be noted. In the *coronatus* × Russian cross, it is quite otherwise. We find that dark disc is uniformly dominant over yellow; the size of the heads in the cross is greater that that of *lenticularis*, but much less than that of the Russian; and the manner of growth is intermediate, at first simple like the Russian, but eventually branching at the top. It is evident that there is some correlation between the manner of growth and the size of the heads, as a plant could not well support more than one big head of the Russian type. A certain incompatibility between the two varieties seems to be indicated by a number of monstrous (fasciated) plants.

The accompanying diagram shows the Russian *coronatus* cross in relation to growth form, and in the third line the expected outcome in 1912.

In Dreer's Catalogue of 1911 appears the following:

The Red Sunflower, *Helianthus cucumerifolius purpureus*. A red annual sunflower has long been looked for, and this new hybrid strain seems to be the forerunner of a really bright red variety, containing as it does a large range of colors, from light pink to deep purplish red.

This is a garden variety of the small *Helianthus debilis*, which we understand originated in Italy. We purchased seed, which produced good plants, but showing hardly any red, and that of a dingy color. We hear from others that this variety has been a great disappointment, but are told that the originator is still working on it. In any event, it is an entirely different plant from ours.

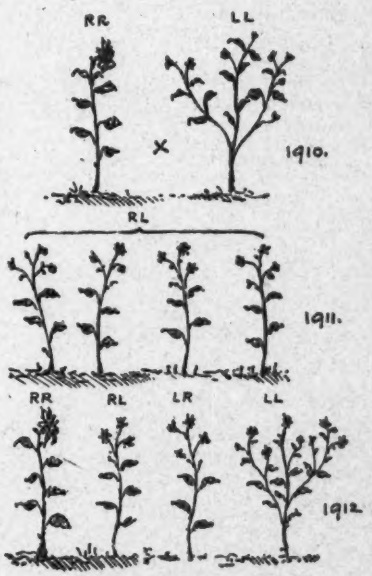


DIAGRAM SHOWING THE CROSS RUSSIAN AND RED SUNFLOWER, the manner of growth of the progeny in 1911 and the expected result for 1912.

A famous discovery somewhat parallel to that of the red sunflower is that of the Shirley poppy, which is described in Bailey's "Cyclopedia of American Horticulture" as "the loveliest of all poppies" and "one of the finest contributions to floriculture ever made by an amateur." The Rev. W. Wilks, of Shirley in England, gives the following account of his discovery and development of this poppy. This was written without any knowledge of Mendelism, and can not at once be reduced to Mendelian terms. It is evident, however, that the Shirley is a *minus* variation (loss of black pigment), and may be expected to behave as a recessive.

In 1880, I noticed in a waste corner of my garden, abutting on the fields, in a patch of the common wild field poppy (*Papaver rhœas*), one solitary flower the petals of which had a very narrow edge of white. This one flower I marked, and saved the seed of it alone. Next year, out of perhaps two hundred plants, I had four or five on which all the flowers were edged. The best of these were marked and the seed saved, and so on for several years, the flowers all the while getting a larger infusion of white to tone down the red, until they arrived at a quite pale pink, and one plant absolutely pure white. I then set myself to change the black central portions of the flowers, from black to yellow or white, and at last fixed a strain with petals varying in color from the brightest scarlet to pure white, with all shades of pink between, and all varieties of flakes and edged flowers also, but all having yellow or white stamens, anthers and pollen, and a white base. . . . My ideal is to get a yellow *Papaver rhœas*, and I have already obtained many distinct shades of salmon. The Shirley poppies have thus been obtained simply by selection and elimination. . . . Let it be noticed that true Shirley poppies (1) are single, (2) always have a white base, with (3)

yellow or white stamens, anthers and pollen, (4) never have the smallest particle of black about them. . . . It is rather interesting to reflect that the gardens of the whole world—rich man's and poor man's alike—are to-day furnished with poppies which are the direct descendents of one single capsule of seed raised in the garden of the Shirley Vicarage so lately as August, 1880.

It is certain that many more good variations would be discovered if trained people were everywhere on the lookout for them, and it must be remembered that among the cereals, for example, a good new strain will not be a conspicuous object like a red sunflower. There is here a fascinating field for amateurs, with possibilities of vastly increasing the wealth of mankind, or adding beauty to his gardens. Aside, however, from the discovery of new things, there is an almost unlimited field open for the crossing of known varieties, and their recombination along Mendelian lines. Any one who has a garden may do this work, and if nothing else comes of it, it will certainly give much pleasure and an insight into some of the most interesting biological problems of the day.

THE MEDICAL SIDE OF IMMIGRATION

By Dr. ALFRED C. REED

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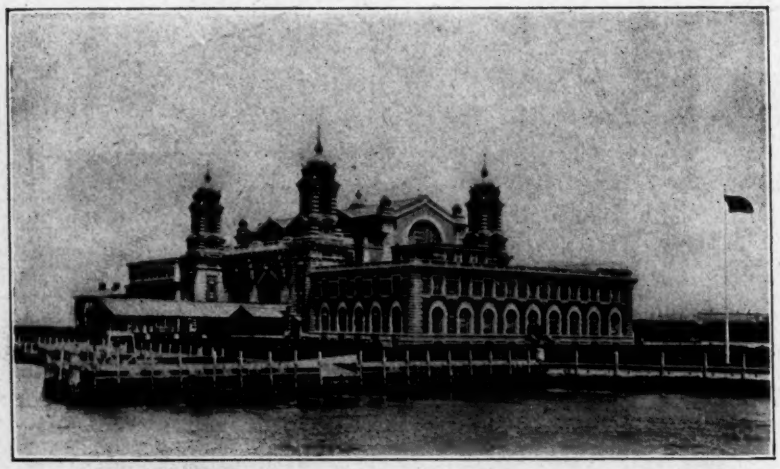
NEW YORK CITY

PERHAPS no question is of more paramount and continuing interest to the American people than immigration in all its phases and relations to public welfare. The history of the United States is the history of alien immigration. The earliest pioneers were themselves alien immigrants. Our institutions, political, religious and social, have been founded and supported by aliens or their near descendants. Our country is indeed a melting-pot, into which have been poured diverse varieties of peoples, from all nations and races. Yet in the face of this, these variant elements have been fused into a more or less homogeneous nation. A national life and character we have. This national or American character is not exemplified in those places where the large streams of immigration are pouring in, but farther away where the waters have mixed. Such a condition, unique in the history of nations, is responsible for certain problems which are also unique in history, and consequently do not admit of solution according to precedents.

The first rule of national life is self-preservation, and since immigration has had and still has so important a rôle in American national life, it must be carefully scrutinized to determine which immigrants are desirable, and *vice versa,* from the standpoint of the betterment and continuance of the American nation. The choice between free immigration, restricted immigration, and absolute exclusion is increasingly difficult to make, and does not enter our field of inquiry, except to recall a principle which is as valid from the medical standpoint as from the economic or social. Only those peoples should be admitted whom experience has shown will amalgamate quickly and become genuine citizens. The period of residence necessary for citizenship should be raised from three to five years, during which time the immigrant should be literally on probation, and subject to deportation if found wanting, or if unable to meet the qualifications of citizenship at the end of that time. The government should decide where the immigrant may settle and the immigration current should be directed to the western and farming districts, and not allowed to stagnate in eastern cities.

The great mass of popular literature on the subject of immigration is singularly deficient in discussion and analysis of its medical features. It is true, the United States government bestows on public health and preventive medicine no where near the attention it finds necessary for the prevention of disease in stock and for agricultural improvement, but

none the less there are certain well-organized and efficiently operated agencies which have for their function the improvement of public hygiene and sanitation, the eradication of preventable disease, and the study of causation and methods of control of diseases. Most of these functions are exercised by the Public Health and Marine Hospital Service, which, strangely enough, constitutes a bureau under the Treasury Department. Some of this work is done under the Department of Agriculture, and other minor lines are scattered elsewhere through the national machinery. It is easily seen how much more efficient would be the work were all these agencies for national health protection united



THE IMMIGRATION STATION, ELLIS ISLAND.

under one administrative head, and their various activities carefully coordinated.

The Public Health and Marine Hospital Service operates all national quarantine stations where inspection is made for yellow fever, typhus fever, smallpox, bubonic plague, leprosy and cholera; maintains hospitals throughout the country for sailors of the American merchant marine; conducts the Hygienic Laboratory at Washington for the study of the causation and treatment of diseases; exercises numerous minor functions of a national board of health; and conducts the medical inspection of immigrants. Certain diseases are found so frequently among immigrants, and others are so inherently dangerous, as to merit special mention because of their important relation to public health.

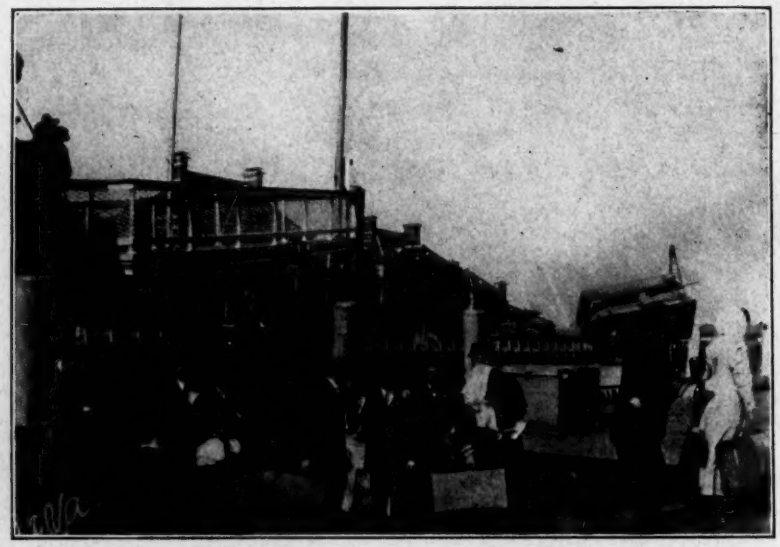
First among these might be placed trachoma, a disease of the eyelids characterized by extreme resistance to treatment, very chronic course and most serious results. Most of the immigrant cases occur in Russians, Austrians and Italians, although it is of common occurrence in oriental and Mediterranean countries. It causes a large percentage of

the blindness in Syria and Egypt. Its contagious nature, together with the resulting scarring of the lids and blindness, make its recognition imperative. The hookworm (*Uncinaria*) has received much attention lately since it has been found so widely distributed through the mountains of the south, the mines of California, the middle west, etc. It is a minute parasitic intestinal worm about three fifths of an inch long, and under the microscope shows relatively enormous and powerful chitinous jaws by means of which it attaches itself to the intestinal walls. The saliva of the hookworm has the curious property of preventing coagulation of blood like leech extract, and when it is remembered that the worms may vary in number from several hundred to a thousand or more, and that each worm moves frequently from place to place on the intestinal wall, it is apparent how excessive and continuous is the drain on the blood and lymph juices. The result is an extreme anemia which brings in its wake a varied multitude of bodily ills, and may eventuate fatally, meanwhile having incapacitated the victim for mental or physical work. Infection can spread rapidly from a single case. Not many hookworm carriers have been discovered among immigrants, probably because the facilities for their detection are so meager. But the heavy immigration from countries where uncinaria is abundant, as well as the recent suggestive work of Dr. H. M. Manning at the Ellis Island Immigrant Hospital, indicate that there is a constant stream of fresh infection pouring in. Indisputably routine examination for hookworms should be instituted. The same can be said of other intestinal parasites as tapeworms, pin worms, whip worms, eel worms and others. One of the tapeworms, the so-called fish worm (*Dibothriocephalus latus*) leads to an anemia fully as severe as that from the hookworm.

Many other diseases might be mentioned, but these are sufficient to illustrate the importance of careful medical inspection of immigrants.

The total immigration into the United States through all ports of entry for the year ending June 30, 1911, was 1,052,649. Of these 22,349 were debarred for various reasons, leaving a net increase of 1,030,300. The chief port of entry is, of course, New York, where 749,642 aliens were examined. Next in order of importance come Boston, Baltimore and Philadelphia, and at a greater distance Galveston, Tampa, San Francisco, Honolulu, Miami and Portland, Me. As the laws are uniform and the methods of inspection the same at all ports, consideration of methods and results at Ellis Island, N. Y., will give a clear idea of the entire subject.

The medical inspecting service at Ellis Island is divided into three branches, the hospital, the boarding division and the line. The hospital division presents an excellently equipped and managed institution, and an isolated set of buildings for contagious diseases. The hospital service is limited exclusively to immigrants, and the patients are those acutely ill upon arrival, those taken sick during their stay on the island,



LANDING FROM BARGE AT ELLIS ISLAND.

and cases of acute sickness among aliens already landed who for some reason have been brought to the island for deportation.

The boarding division of the medical inspection on Ellis Island has for its particular function the inspection of aliens in the first and second cabins on board the incoming vessels. Those who require more detailed examination are sent to Ellis Island.

The routine inspection on the line is that part which the visitor sees, and is the most important feature of the medical sieve spread to sift out the physically and mentally defective. The incoming immigrants pass in single file down two lines. Each of these lines makes a right-angled turn midway in its course. At this turn stands a medical officer. He sees each person directly from the front as he approaches, and his glance travels rapidly from feet to head. In this rapid glance he notes the gait, attitude, presence of flat feet, lameness, stiffness at ankle, knee, or hip, malformations of the body, observes the neck for goitre, muscular development, scars, enlarged glands, texture of skin, and finally as the immigrant comes up face to face, the examiner notes abnormalities of the features, eruptions, scars, paralysis, expression, etc. As the immigrant turns, in following the line, the examiner has a side view, noting the ears, scalp, side of neck, examining the hands for deformity or paralysis, and if anything about the individual seems suspicious, he is asked several questions. It is surprising how often a mental aberration will show itself in the reaction of the person to an unexpected question. As the immigrant passes on, the examiner has a rear view which may reveal spinal deformity or lameness. In case any positive or suspicious evi-

dence of defect is observed, the immigrant receives a chalk mark indicating the nature of the suspicious circumstance.

At the end of each line stands a second medical officer who does nothing but inspect eyes. He everts the eyelids of every person passing the line, looking for signs of trachoma, and also notes the presence of cataract, blindness, defective vision, acute conditions requiring hospital care and any other abnormalities. All cases which have been marked on the line are separated from the others and sent to the medical examining rooms for careful examination and diagnosis. When it is remembered that often 5,000 immigrants pass in a day, it is clear that the medical officers not only are kept busy, but that they see an unusually wide variety of cases.

After careful examination, the nature of the defect or disease found, is put in the form of a medical certificate which must be signed by at least three of the physicians on duty. It is not within the province of the medical officers to pass judgment on the eligibility of the immigrant for admission. The medical certificate merely states the diagnosis, leaving to the immigration inspector in the registry division the duty of deciding the question of admission. In the inspector's consideration are included not alone the medical report, but all other data concerning the applicant, such as age, money in his possession, previous record, liability to become a public charge, and his sponsors.

Most cases of trachoma and mental or organic nervous disease are sent to the hospital and kept under care and observation to facilitate an accurate diagnosis. Seldom indeed does the alien suffer from too harsh a medical judgment. He is given the benefit of a doubt always. For example, if a case of defective vision is found to be 3/20 normal, it would be certified as perhaps 5/20 normal.

The immigration law as it stands since the legislation of 1907, divides all defective immigrants into the following classes: Class A, aliens whose exclusion is mandatory because of a definite and specified

LINED UP, WAITING FOR THE MEDICAL EXAMINATION.

defect or disease. Class B, aliens not under class A, but who possess some defect or disease which is likely to interfere with the ability to earn a living. Class C, aliens who present a defect or disease of still lesser seriousness, not affecting ability to earn a living, but which none the less must be certified for the information of the immigration inspectors.

Under class A, the excluded, are listed idiots, imbeciles, the feeble-minded, the epileptics, the insane, persons afflicted with tuberculosis of the respiratory, intestinal or genito-urinary tracts, and loathsome or dangerous contagious diseases. By contagious the law means communi-

A COSMOPOLITAN GROUP ON THE ROOF OF THE DETENTION QUARTERS.

cable. Loathsome contagious diseases include those whose presence excites abhorrence in others, and which are essentially chronic, such as favus, ringworm of the scalp, parasitic fungus diseases, Madura foot, leprosy and venereal disease. Dangerous contagious diseases are such as trachoma, filariasis, hookworm infection, amœbic dysentery, and endemic hematuria.

Under class B, diseases and defects not in class A but which affect ability to earn a living, are such conditions as hernia, organic heart disease, permanently defective nutrition and muscular or skeletal development, many deformities, varicosities of the lower extremities, premature senescence and arterial degeneration, certain nervous diseases, chronic joint inflammations, poor vision and tuberculosis of the bones, skin or glands. The immigration law makes no distinction between

cabin and steerage aliens, and the medical officer has no duty beyond the purely medical inspection.

Commissioner of Immigration Williams for the Port of New York in his recent report[1] for the fiscal year ending June 30, 1911, makes some pertinent observations and recommendations regarding the medical phases of the immigration question at Ellis Island. He finds that the present medical quarters are not large enough for the proper execution of the laws relating to physical and mental defectives. Expansion to an appropriate size is prevented by the failure of Congress to appropriate the funds requested. He notes the large number of feeble-minded children in the schools of New York City who have passed Ellis Island, and gives as one reason, lack of time and facilities for thorough examination as to mental condition. The result is that the law in this particular is practically a dead letter. According to the law, the feeble-minded as well as idiots and imbeciles are absolutely excluded. It is of vast import that the feeble-minded be detected, not alone because they are predisposed to become public charges, but because they and their offspring contribute so largely to the criminal element. All grades of moral, physical and social degeneracy appear in their descendants, and it is apparent how grave is the social and economic problem involved. The steamship companies do not exercise proper precautions in receiving immigrants for passage, and this makes all the more necessary a rigid inspection at the port of entry into this country.

The report of the Chief Medical Officer on Ellis Island, Dr. G. W. Stoner,[2] shows that during the year ending June 30, 1911, nearly 17,000 aliens were certified for physical or mental defect and over 5,000 of these were deported (not necessarily for medical reasons alone). Among those certified were 209 mental defectives, of whom 45 per cent. were feeble-minded, and 33 per cent. insane. Under loathsome and dangerous contagious diseases there were 1,361 cases, of which 85 per cent. were trachoma. Over 11,000 aliens had a defect or diseases affecting ability to earn a living and half of these were due to age and the changes incident to senescence. More than 4,000 certificates were rendered for conditions not affecting ability to earn a living.

Over 6,000 aliens were treated in the immigrant hospital, beside 720 cases of contagious disease, which were transferred to the State Quarantine Hospital at the harbor entrance before the completion of the present contagious-disease hospital on Ellis Island. Among these 700 there were a hundred deaths, chiefly from measles, scarlet fever and meningitis. The medical officers also examined 168 cases which had become public charges in surrounding towns of New York, New Jersey

[1] Williams, Wm., Commissioner of Immigration for Port of New York, Annual Report for year ending June 30, 1911.

[2] Stoner, G. W., M.D., Chief Medical Officer, Ellis Island, Annual Report for year ending June 30, 1911.

FROM HOLLAND.

and Connecticut to determine the nature of the illness and if due to causes existing prior to landing. Chief among the contagious diseases were measles, chicken-pox, diphtheria and scarlet fever. The quarantinable diseases, cholera, leprosy, bubonic plague, smallpox, typhus and yellow fever are removed at the New York Quarantine Station before the vessels are docked.

Statistics such as these inevitably suggest a brief consideration of the different sources of immigration and their relative desirability from the medical standpoint. In general it may be said that the best class is drawn from northern and western Europe, and the poorest from the Mediterranean countries and western Asia. Among the worst are the Greeks, South Italians and the Syrians, who emigrate in large numbers. The Greeks offer a sad contrast to their ancient progenitors, as poor physical development is the rule among those who reach Ellis Island, and they have above their share of other defects.

The old question of the desirability of the Hebrew must be settled on other grounds than those of physical fitness alone, although even here the medical evidence is decidedly against him, as Dr. McLaughlin[3] has shown that the proportion of defectives to total landed is greatest among the Syrians, 1 in 29, and next greatest among Hebrews, 1 in 42. Contrary to popular belief, the Jewish race is far from a pure stock, and has been colored by various and repeated admixtures with other bloods. Hence Jews of different nationalities differ considerably in their physical status and aptitude for American institutions, and for amalgamation

[3] McLaughlin, THE POPULAR SCIENCE MONTHLY, Vol. 62, p. 234.

with our body politic. No race is desirable which does not tend to lose its distinctive traits in the process of blending with our own social body. It would seem from history that the Jew only blends inadvertently and against his conscious endeavor and desire. Hence the process of true assimilation must be very backward. Moreover, in origin, racial traits, instincts and point of view, the Hebrew race is essentially oriental, and altogether there is at least ground for objection to unrestricted Jewish immigration.

No one can mistake the pressing necessity for a solution of the immigration problem. The problem of New York City in this respect is unique and differs from that of the rest of the country, because as Walter Laidlaw[4] points out, New York City is in reality a foreign city, inasmuch as in 1910 the native-born of native parents numbered only 193 in every 1,000 inhabitants. This preponderating foreign element is due to the concentration of arrested immigration in New York. For the country as a whole, great interest attaches to the influence which the Panama Canal will exert in diverting immigration lines to southern and Pacific coast points. New local problems will of course arise, but the basic proposition remains always the same. Immigration should be restricted absolutely to such races as will amalgamate, without lowering the standard of our own national life.

In general, immigrants from the Mediterranean countries should be excluded, especially those from Greece, South Italy and Syria, as well as most Hebrews, Magyars, Armenians and Turks. Strict enforcement

NEGROES FROM THE WEST INDIES.

[4] Laidlaw, Walter, *New York Times*, December, 1911.

of the present medical laws will automatically exclude these races to a sufficient extent, admitting the few who are fit. This, combined with a strictly enforced five-year probation period, with deportation as the penalty for any criminal conviction or for failure to qualify for citizenship afterward, would go far toward relieving the situation. This need not disqualify aliens from travel in the United States.

The immigrant per se has no moral or social right to enter this country against the will of its citizens. An enduring commonwealth must of necessity guard rigidly the health of its citizens and protect itself against undesirable additions from without. There was a time when European immigration was free, and almost entirely of desirable classes. That time has passed. The less desirable classes are increasing actually and relatively, and at the expense of the more desirable. It can truthfully be said that the dregs and off-scourings of foreign lands, the undesirables of whom their own nations are only too eager to purge themselves, come in hosts to our shores. The policy of those advocating free immigration would make this country in effect the dumping ground of the world.

Exclusion of these undesirables works no injustice to the lands from which they come. A large emigration from a land usually is followed by an increased birth-rate, and the net change is slightly affected, if at all.[5] Admitting undesirables to this country will in no wise elevate the world's human standard, because those undesirables will multiply as fast here as in their original home, and their stock will only become extinct when it ceases to perpetuate itself. High requirements for admission to this country reflexly raise standards of living and education in those lands from which our immigrants are drawn. This was illustrated in Italy[5] a few years ago when the higher requirements for admission caused an enforcement of the primary education laws which were dead letters before. Again, increase of a poorer class of immigration decreases the number of the better class and also decreases the chances of those who do come.

The medical phases of immigration blend very quickly into the subjects of national health protection, national eugenics and even the future existence of the ideals and standard of life which we are proud to call American. Conservatism and a carefully maintained medium between absolute exclusion, and free immigration, certainly seems the best policy.

[5] Hall, Prescott, F., "Eugenics, Ethics and Immigration."

ANCIENT PORTALS OF THE EARTH

By Professor JAMES PERRIN SMITH

STANFORD UNIVERSITY, CALIFORNIA

Portals Defined.—A study of the distribution and relationships of ancient marine faunas shows that there have been certain critical areas through which these faunas were connected from time to time. These critical areas are depressions on or between continental masses, and are invariably regions of permanent instability of the earth's crust, where mountain-making and the accompanying volcanic and earthquake disturbances have been prevalent.

When these areas were depressed below sea-level, they formed straits, or channels, connecting sea-basins, and affording avenues for intermigration of marine faunas. When they were elevated, they formed barriers impassable to the dwellers in the sea. Thus neither the name strait nor barrier is applicable to them as a general term. Therefore the name *portal* is selected, as indicating a gateway that may be either open or closed, and still retain its identity.

Of the portals that were important in the ancient world only three are now open: the North Pacific portal, of which Bering Strait is a shrunken remnant; the Iberian, still recognizable in the Strait of Gibraltar; the Malaysian, seen in the inter-island passages in the East Indian Archipelago. And one has shifted its position, growing from an arm of the sea into the noble expanse of the Indian Ocean.

One still shows its nature as a portal in the narrow strip of land joining the two Americas. The others are now concealed as parts of continental masses, namely the Crimean, the Asia Minor portal, and the Bokharan, revealing their nature as former arms of the sea only in the extinct marine fossils now buried in their sediments.

Still other bodies of water that loom up large in our present-day geography, as the North Atlantic and the South Atlantic, too wide to be called merely passages, or to be differentiated from the main ocean by a special name, did not even exist in the ancient days.

These great changes have been wrought chiefly by the world-wide Tertiary mountain building, and the accompanying, or causing, disturbances of the continental areas. Also there was much readjustment in the late Paleozoic topographic revolution, and in the late Jurassic Cordilleran revolution.

Paleogeography.—In recent years the reconstruction of ancient physical geography has been a favorite field of research, not to say of speculation, of geologists; paleontologists, too, have taken their part in

this, since ancient continents can be outlined only by the distribution of the faunas and floras of the land, and ancient seas can be traced only in the remains of petrified inhabitants of the waters.

In the Book of Genesis we read: "And God said, Let the waters under the heaven be gathered together into one place, and let the dry land appear; and it was so. And God called the dry land Earth; and the gathering together of the waters called He seas: and God saw that it was good." This is certainly the shortest account of the origin of continents and seas, and probably as good as any. But we do not any longer think that it all happened at one time.

Since we can know definitely the geology of only that part of the earth which is now land, and since we know the underlying strata of only a small part of that, we can only conjecture concerning the history of regions now buried under the oceans. No one man, nor group of men, is qualified to make a dogmatic statement as to the origin of continents and seas, such as that quoted above from Holy Writ. There is ample room for differences of opinion, starting from the same facts. Consequently, geologists and physical geographers are divided into two camps. One holds that the major divisions of land and sea were always as they now are; this is the doctrine of permanence of continental plateaus and oceanic basins. The other group advocates the idea of constant change in the position of land masses and oceanic troughs. To them the grand features of the earth do not bear the marks of hoary antiquity, but are youthful characters, due to rather modern diastrophism of the crust.

The truth probably lies somewhere between the two extremes, and the differences between the two camps consist rather in statement than in fundamental doctrine. Even the most conservative upholders of the theory of permanence admit that some of the continental areas have been covered, in the past, by seas of almost oceanic size and depth. And the most radical advocates of the shifting of lands and seas believe that some of the continental masses have always been continents, and that some of the great depressions have always been oceans.

Further, it becomes plainer, as paleogeographic studies go deeper into the history of the earth, that the dominant ancient features are not obliterated by later changes, but are merely obscured. Continents that were dismembered have been united again; seas that existed in the early days have recurred. Which is to say that whether continental plateaux and oceanic troughs have been permanent or not, the regions of diastrophism have been permanent, that when crumpling and dislocation of the earth's crust have once started, they have kept up with recurrent activity all through the succeeding ages.

The ancient portals all lie in regions where the Tertiary mountain folds touch the great lines of crumpling begun in the late Paleozoic topographic revolution. The present distribution of continental pla-

teaus and oceanic troughs dates from the Permo-Carboniferous revolution, although the North Atlantic and the South Atlantic were not occupied by the sea until early Tertiary time.

During Cambrian time the Bering, Central American, Iberian, and Asia Minor portals were open, probably corresponding to regions of Pre-Cambrian folding. The others had not yet come into existence, or at any rate information is lacking concerning them. In the Lower Silurian we know of the existence of the Bering portal. During the Devonian the Bering and the Asia Minor portals were open all the time, the Crimean part of the time, while the Bokharan portal was merely part of the open Asiatic sea. During the Carboniferous era all the major portals were open at times except that leading down to Madagascar. Somewhere near the border between Coal Measures and Permian the Paleozoic topographic revolution inaugurated centers of distribution and portals connecting them that held sway during nearly the whole of Mesozoic time.

If diastrophism should be the final arbiter of the division of geological time, then on the basis of physiography the Permian, including the Artinsk stage, should be included in the Mesozoic. For while Permian life is distinctly more closely related to that of the Paleozoic, Permian physiography is like that of the Triassic.

Interregional Faunal Zones.—It is customary to speak of cosmopolitan faunas in the past ages, but this term is properly applicable only to the Cambrian and Silurian, when local differentiation had not yet caused the extremes of later times. And even in the Cambrian, as the scanty faunas become better known, provincial differences appear.

In Devonian time provincial distinctions were already well developed, and the invasion of a region by an exotic fauna is easily recognized. The first interregional migration that is definitely known occurred early in the Upper Devonian, when the American waters were invaded by a fauna that could not have sprung from its predecessors in that region, but was endemic in Eurasia. This is the zone of the *Cuboides* fauna, which was followed by still further immigration from the same center of dispersion, in the zone of *Manticoceras intumescens* of the Upper Devonian. The connection with Europe was through the back door, through northern Siberia, across North America, for the continental mass of North Atlantis and Appalachia prevented direct communication.

With the opening of the Carboniferous age the subsidence of the southern part of Appalachia allowed direct intermigration between the waters of western Europe and the Mississippian Sea through the Poseidon basin. Here we find the faunal zone of *Aganides rotatorius* common to the two regions, but unknown anywhere else. This is the first direct invasion of the American seas by a population from the western Tethys, or ancient Mediterranean basin. In the latter part of

the Lower Carboniferous epoch another migration from western Europe to the Mississippi basin took place; this was in the zone of *Goniatites striatus,* which, as was the case with the preceding zone, did not extend beyond the Mississippian Sea. At this time in the western part of North America, the Great Basin Sea was connected with northern Asia, and through that region with Europe. The Pacific region lacks the fauna of *Goniatites striatus,* but has, instead, that of *Productus giganteus.* Here, for the first time, we see a sharp differentiation into Mediterranean and Pacific types of faunas, separated by the land barrier of the Rocky Mountain area.

In the age of the Coal Measures we find further evidence of continued invasion of the Mississippian Sea by immigrants from the western European Tethys, in the faunal zone of *Gastrioceras Listeri.* This group was common in the shallow epicontinental expansion of the old Mediterranean Sea, and reached America along the shores of the Poseidon Ocean, the Paleozoic ancestor of the modern Atlantic, and into the Mississippian basin through the Gulf of Mexico, up into Arkansas, Texas, Oklahoma, Missouri, Kansas, Illinois, etc. But the western sea of the Great Basin was dominated by a fauna from the boreal waters, which came down through the Bering portal, along the old shore line of northwestern America. The Mediterranean fauna extended eastward through the Tethys to Sumatra, and up into the Ural Mountains, showing that the Iberian, the Bokharan, and the Asia Minor portals were all open. The Malaysian portal was apparently closed, and the Madagascar geosyncline as yet shows no evidence of its existence.

The Artinsk, or Permo-Carboniferous transition, fauna has approximately the same regional distribution as that of the zone of *Gastrioceras Listeri,* except that it reached further northward, to Nova Zembla. But while the Carboniferous cephalopod fauna may be considered as Mediterranean in origin, the Artinsk fauna probably came from further east; its real home seems to have been on the border between Asia and Europe, for there it is most abundantly developed, and bears the closest resemblance to its predecessors.

At this time the northern Asiatic-Pacific fauna had a different character, but is as yet little known. In America it is known in California, and in the southern embayment that stretched from the Pacific to western Texas. It is called the Guadalupian fauna, from Guadalupe Mountains in Texas, where it was first described. In Texas these two faunas, the Artinsk and the Guadalupian, come within a few hundred miles of each other. The east and the west, the Atlantic and the Pacific, were separated then, as they were during most of the Carboniferous.

On the west, the Guadalupian or Pacific fauna, penetrated the Great Basin Sea, but did not extend far inland on the continent, the high lands of Utah and Idaho still separating it from the Cordilleran extension of the Mississippi sea.

During at least a portion of the Permian the Bering portal was open, the Central American closed, the Iberian, Asia Minor, and Bokharan portals open, and the Malaysian portal closed, for the characteristic cephalopod fauna, with *Medlicottia* and its associates, occurs in Texas, Sicily, the Ural Mountains, Nova Zembla, the Himalayas, and Timor in the Indian Archipelago. The Pacific, or Guadalupian type, on the other hand, is distributed from Japan around the old Pacific shore line to California, and in another gulf across the more southerly part of the American continent to western Texas.

At the end of the Paleozoic era there was much mountain-making, and readjustment of physiography. These disturbances separated some regions that had been united, and joined others that had been divided. In the earliest epoch of the Lower Triassic, the zone of the *Meekoceras* fauna, the Asia Minor portal, through which the Artinsk fauna had migrated between the western Mediterranean and the Oriental Tethys, was closed, while the Malaysian portal into the Pacific was open. The barrier between the Atlantic and the Pacific still existed in Central America. The *Meekoceras* fauna is distributed from Spitzbergen, down to India, eastward to Timor in the Indian Archipelago, with a southward arm of the sea extending down to Madagascar, connecting with the Pacific, stretching along the Siberian coast at Wladiwostok, and then across to Idaho and California in the Great Basin Sea.

The next fauna in the Lower Triassic, that of the *Tirolites* zone, is known only in the Mediterranean Region and in Idaho, the connection being from the Mediterranean-Poseidon Ocean to the Pacific, through the Central America portal, which was temporarily opened by subsidence in that region. All the other portals were closed, so far as we have any information concerning them, this conclusion being based on the provincial character of the faunas of the seas.

In the epoch immediately following, the *Columbites* zone, is seen the same provincial, or restricted distribution of inhabitants of the seas. The *Columbites* fauna is found in Idaho, in northern Siberia, and in Albania, but not in India, nor the Oriental Tethys. At this time the Arctic Sea was the center of dispersion, and immigrants went southwestward to Albania, and southeastward to Idaho, but did not reach the Indian waters, in which a different group of inhabitants lived.

In the Middle Triassic the Asia Minor portal and that of Central America were reopened, and the *Ceratites trinodosus* fauna, with the Mediterranean as its center of dispersion, was distributed westward through the Poseidon-Atlantic to Idaho, and eastward to India. There was also some connection northward to Spitzbergen, and southward to New Zealand, for the binular genus, *Daonella,* is represented by nearly identical species in all these regions.

In the Karnic horizon zone of *Tropites subbullatus,* in the Upper Triassic, the same connections still existed, with even closer relation-

ships of widely separated faunas. A large proportion of the Karnic species of India is identical with the Mediterranean fauna, and in California about one third are common forms in the Alps and Sicily.

Immediatelly above the beds with *Tropites subbullatus* in India, the Alps, and in California occur massive limestones full of coral reefs, with some few identical species in all three regions. This same group of ancient reef-builders has also been found in Alaska, in the same stratigraphic position. This shows that the wide distribution of the Upper Triassic species was made possible by the nearly uniform distribution of warm water over a great part of the globe.

In the latter part of the Upper Triassic widespread physiographic disturbances had again divided the great zoologic regions. The Atlantic-Pacific connection had disappeared, but there was still free communication between the Alpine province and the Orient, for Mediterranean species reached as far as India and Timor. Around the North Pacific, with the Arctic sea as its center of dispersion, a different fauna, that of the bivalve, *Pseudomonotis ochotica,* was distributed. This extended from northern Siberia southwestward to the Crimea, southeastward to the Great Basin Sea, and southward along the shores of Asia through Japan to New Zealand.

In the Lower Jurassic we find a recurrence of the same conditions that prevailed in the Karnic epoch, free communication through the Central American and Asia Minor portals, and between the Pacific and the Oriental Tethys, with nearly identical species ranging from the far north to the south temperate region in Argentina, and from the Mediterranean eastward to Timor and westward to California.

In the Middle Jurassic similar geographic relations continued, with clear evidence of a warm climate from Franz Joseph Land to Madagascar and Argentina, and no division into climatic zones. Cycads flourished on the land, and corals built reefs in the seas. This was too good a state of affairs to last long in this world, and there soon came a change. The Central American portal was closed, as was that between the Pacific and the Tethys. The Arctic Sea became the center of dispersion of a boreal fauna, which made its way down to Russia on one side, and to California and Mexico on the other. This arrangement of the geographic provinces reminds us strongly of that during the Triassic epoch of *Pseudomonotis subcircularis,* and it continued into the Cretaceous period.

The Upper Cretaceous is signalized by the closing of the Bering portal, and the wide distribution of a tropical fauna from the Indian waters westward to the Mediterranean waters, and eastward through Japan, around the North Pacific shore-line to California. This same fauna was also distributed from the Mediterranean westward through the Poseidon Sea to Mexico, and southward into South America. And

a southern arm of the Oriental Tethys carried the same assemblage of forms down to South Africa.

The early Tertiary Eocene epoch witnessed the reopening of the Central American portal, and the immigration of the Mediterranean *Venericardia planicosta* fauna into the Pacific waters of the Californian province. This is the last true interregional zone in the history of the earth, and it is the last time when widespread warmth of the waters made such distribution possible. Since that time the Central American and the Asia Minor portals have been closed, and the continually increasing demarcation of climatic zones have prevented migration between the greater sea basins through northern waters. The later Tertiary epoch witnessed the inauguration of modern conditions, and the geographic regions were restricted as they are now.

PTOMAINES AND PTOMAINE POISONING

By EDWIN Le FEVRE, A.B., M.D.

THE subject of food poisoning is one that is commanding a constantly increasing attention on the part of the general public. A brief résumé therefore of the most important facts relating to ptomaines and ptomaine poisoning together with some deductions based thereon may be of interest to all who would be informed on matters relating to their physical welfare—certainly so to those who are practical conservators of the public health.

Ptomaines are chemical compounds of an alkaloidal nature formed in protein substances during the process of putrefaction. In order to a clear understanding of the subject, emphasis is to be laid on the fact that they are purely *chemical* bodies formed out of the medium in which they occur.

In this respect they are to be differentiated from the toxins, which are poisons of unknown composition, formed within the bacterial cell itself and in the case of certain organisms, given off to the medium in which they grow. They are also to be differentiated from another class of compounds known as leucomaines, which may in some instances be of like chemical composition, but which are formed only within the living body, usually as the result of tissue metamorphosis. From these, when not properly eliminated, we get the varied phases of auto-infection.

Putrefaction is the biochemical process by which all protein matter is reduced to the inorganic state from whence it came, thus completing the life cycle. This change is brought about by the action of micro-organisms. A certain group of bacteria have the power to split up the complex protein molecule and thus form new and simpler compounds. As a result of their action we have formed first albumoses and peptones and from these we have formed the amino acids which are the great foundation stones of the proteins. These are still capable of sustaining bacterial life and the splitting-up process continues. As a result we may get a large number of products, solid (crystalline), liquid and gaseous—and among them may be some of the basic compounds which we call ptomaines.

So far about sixty ptomaines have been isolated and studied and of these about one half are more or less poisonous. It is to be borne in mind that the so-called ptomaines are not a distinct class of chemical compounds, but differ widely both in chemical composition and physical characteristics. Indeed it may be said that they have only this in common, that they are basic and contain nitrogen. Some of them are comparatively simple and well-known organic compounds like the simple

amines, others are much more rare and complex; "some are strongly alkaline and basic, others but feebly so; some are liquid, oily and volatile, others fixed and crystalline; some are very prone to change, others quite stable."

Two thirds of the known ptomaines contain only carbon, hydrogen and nitrogen. These represent the simple ammonia substitution compounds. All those that contain oxygen in addition (the so-called oxygenated bases) possess the trimethylamin molecule as their basic constituent.

Gautier has probably given the best classification of the ptomaines. He divides them into the following groups:

Monamines of the fatty acid series.

Diamines of the fatty acid series.

Guanidines.

Aromatic ptomaines free from oxygen.

Oxygenated ptomaines.

Aromatic oxygenated bases.

Unfortunately the isolation of a ptomaine from any decomposed or putrid material is a very difficult matter. This is true largely because of the great number, complexity and diversity of the other substances present in the decomposing mass and the fact that these may be at varying stages of putrefaction.

Some of the ptomaines are volatile and are decomposed at any temperature near that of boiling water. Others, very prone to undergo decomposition, may be destroyed by the action of the reagents used. Hence efforts to determine their presence and character are very apt to be attended with failure. In all of these cases, however, where a sufficient amount of a suspected food can be obtained an attempt should be made to determine the presence of any decomposition products that may have been responsible for toxic symptoms. In every case the chemical analysis must be supplemented by a bacteriological examination (much more promising of results) under both aerobic and anaerobic methods to determine the character of the microorganisms present. From pure cultures thus obtained inoculations should be made in suitable animals to determine their infectious character and filtered cultures used to determine the presence of soluble toxins.

It is quite probable, as the more recent investigations have shown, that many cases of food poisoning ordinarily classed as of ptomaine origin are in reality due to a direct infection by bacteria in the food which possess pathogenic properties or to toxins formed by them. The tendency to designate all bacterial food poisoning as ptomaine poisoning is not therefore strictly in accord with the facts as we now know them.

The resemblance of the ptomaines to the vegetable alkaloids has been noted. These two groups of compounds resemble each other in

their chemical composition and to a certain extent in their physiological action. The ptomaines have sometimes been called the animal alkaloids. This, however, is misleading, as ptomianes may be formed in vegetable as well as in animal proteins. Their essential difference is to be found in their origin. The ptomaines are decomposition products and largely belong to the aliphatic series, whilst the true plant alkaloids are cyclic compounds and practically all of them pyridin derivatives. Owing to the wide variation in the chemical constitution of the ptomaines no analytical methods are known or possible by which they can be differentiated as a class from the vegetable alkaloids. This is possible in the case of certain ptomaines but not all. As a result of this it is not difficult to see how serious medico-legal problems may arise. It is believed in not a few instances ptomaines have been mistaken for the vegetable alkaloids in chemico-legal analyses.

For our knowledge concerning the ptomaines we are indebted very largely to the investigations of Selmi, Nencki, Gautier and Brieger. Selmi was the first (1874–77) to suggest the name—ptomaine—and in fact the first to announce their true nature and origin. Nencki was the first (1876) to isolate a ptomaine (collidine) in pure form and determine its chemical formula. Gautier has given the best classification of both the ptomaines and leucomaines. To Brieger, however, belongs the credit of isolating the largest number (nearly one half) of the known ptomaines and of giving us the best methods for their determination. Vaughan and Novy in this country have made some valuable researches along this line. As the result of an investigation of a number of cases of cheese poisoning they succeeded in isolating a substance which when administered to animals produced symptoms quite similar to those caused in the human subject by the poisonous cheese. To this they gave the name tyrotoxicon. This poison or one very similar has also been isolated from ice cream and milk. The chemical composition of tyrotoxicon has not as yet been definitely determined.

In foods like cheese and certain sausages which depend for their flavor on the action of certain microorganisms it is not strange that we should at times have the formation of poisonous compounds. The so-called process of "ripening" as applied to food products is in fact a partial putrefaction in which we have as the result of bacterial action the formation of ammonia compounds and amino acids which render the food more palatable. It is therefore not a matter of surprise that we should have at times a condition of "over-ripening" with the formation of chemical compounds of a poisonous character. It is to be borne in mind that ptomaines are not found only as the result of advanced putrefaction. Rather are they the products of the earlier stages of protein decomposition. In advanced putrefaction they may themselves be broken down into more simple compounds. Thus

Brieger isolated from a putrid mixture a ptomaine (peptotoxin) which he was unable to find when the putrefaction was more advanced.

The symptoms of ptomaine poisoning vary in kind and severity, depending on the nature and quantity of the poison consumed. These may be wholly or in part referable to the gastro-intestinal system. As a result we may have vomiting, abdominal pain, diarrhea or constipation, usually attended with great prostration. In a majority of the cases there is evidence of involvement of the central nervous system and in some cases the symptoms are wholly of a nervous character. Prominent among these are disturbances of vision and dryness of the mouth and throat. There may be fever or a subnormal temperature. Very often there is great weakness, rapid pulse and a tendency to collapse. Other symptoms which may or may not be present are vertigo, dyspnoea, convulsions, delirium and various skin eruptions. In some cases the symptoms simulate very closely poisoning by one of the vegetable alkaloids.

There is little room to doubt that many cases of acute illness are the direct result of some form of bacterial poison consumed with the food but which in isolated cases are not always recognized as such and often called by other names. It might be said that this factor in causing sickness finds but scant recognition save in those instances where a number of persons in a community are similarly stricken at the same time.

The prophylaxis of ptomaine poisoning resolves itself into the prevention as far as possible of the bacterial invasion and decomposition of our foods and food products. Certain foods like chopped meats, cooked potato and milk and the milk products lend themselves most readily to the growth of microorganisms and for this reason are to be the more carefully guarded.

Canned goods, especially the canned meats, are frequently the source of ptomaine poisoning. This results from the fact that they are not always perfectly sterilized before sealing, and, being often held in storage for a long time, an excellent opportunity is afforded for the formation of putrefactive poisons. Canned goods should in no case be consumed if there is any evidence of gas formation as shown by "blown" cans or the escape of gas on opening the can or, if there is any rancidity or putridity of the contents.

Fish, oysters and other sea foods undergo putrefactive changes very speedily and in so doing are very prone to form poisonous products. Several of the ptomaines were first isolated from the decomposed flesh of fish. Mitilotoxin (possibly a leucomaine), the most powerful of this class of poisons, was first obtained from mussels.

Great care should be taken to avoid eating fish or any of the sea foods which show the slightest evidences of putrefaction.

Heat of sufficiently high degree is destructive to all bacteria and is

largely depended upon to render harmless any disease-producing germs that may be contained in our food. While this is true of bacteria it is not true of all the products formed by them. Certain ptomaines and toxins may be destroyed by heat. Others are not susceptible to its influence. Therefore heat as employed in the process of cooking can not be regarded as a safeguard against ptomaine poisoning. Moreover it is often after cooking that these poisons are formed. Many of our cooked foods constitute the very best kind of culture media and as a result putrefactive changes may take place in them very rapidly. The safe plan is therefore to eat food soon after cooking or if it is reserved for any length of time it should be well protected from bacterial invasion and kept at a low temperature.

Cleanliness and low temperature afford the best means at our command for preserving foods from bacterial action—cleanliness to prevent the presence and contaminating influence of the millions of bacteria, often of the putrefactive type, which are always to be found where dirt and filth of any kind is allowed to accumulate and where flies and other insects are given free access, and low temperature to prevent the multiplication of those already in the food, no matter how careful we may have been to exclude them. Cold, even a freezing temperature, is not fatal to bacteria, but it does decidedly retard their growth. Even at the temperature of the ordinary refrigerator (about 10° C. or 40° F.) we find that most organisms multiply very slowly and as a result putrefactive changes are much retarded. Refrigeration is therefore a necessity for the proper keeping of foods, at least during the hot season. But to be efficient the refrigerator must be properly managed. Unless it be kept clean, properly ventilated and well supplied with ice it is practically useless, in fact absolutely dangerous.

Public sentiment is now demanding that those who produce and handle our foods should furnish them to us in a pure and wholesome condition and sanitary officials on every hand are endeavoring to enforce the proper regulation and protection of our food supply. This effort is most commendable. It is well to remember, however, that official regulation can extend only to our doors and to be fully effective it must be supplemented by proper management in our homes and in all places where food is consumed.

In conclusion, we must admit that well-defined cases of ptomaine poisoning are comparatively of rare occurrence when we consider the amount of food consumed and the number of consumers. They would indeed be exceedingly rare if those who are charged with the preparation and handling of our foods would always exercise the proper precautions along the lines we have indicated.

SCIENCE AND INTERNATIONAL GOOD WILL

By J. McKEEN CATTELL

SCIENCE with its applications has been one of the principal factors leading to peace and international good will. Science, democracy and the limitation of warfare are the great achievements of modern civilization. They have advanced together almost continuously from the beginnings of the universities of Bologna, Paris and Oxford in the twelfth century to their great triumphs in the nineteenth century and the present promise of their complete supremacy. It may be urged reasonably that science is the true cause of democracy and that science and democracy together are the influences most conducive to permanent and universal peace.

The applications of science in industry, agriculture and commerce, in the prevention of disease and of premature death, have abolished the need of excessive manual labor. It long ago became unnecessary for the great majority of the people to be held in bondage in order that a few free citizens might have education and opportunity, and slavery has been gradually driven from the world. The vast progress of scientific discovery and invention in the nineteenth century has reduced to a moderate amount the daily labor required from each in order that all may be adequately fed, clothed and housed. The death-rate has been decreased to one half; the ensuing lower birth-rate has freed nearly half the time of women and reduced proportionately the labor of men. The period of childhood and youth may be devoted to universal education, and equality of opportunity can be given to all. It is no longer needful to depend on a privileged class to conduct the affairs of government and to supply men of performance. Those selected from all the people as most fit can be given the preparation and opportunity needed to enable them to become leaders, and every one can take an intelligent share in political affairs and in appreciation of the higher things of life.

In giving us democracy science has made its greatest contribution to the limitation of warfare. It must be admitted that a democratic people may be inflamed into a mob mad for war; but this is not likely to happen in the case of a war of policy or of aggression. In the past wars have been more often due to the ambitions, difficulties and intrigues of kings and princes than to the passions of the people, and the decrease of wars has been largely a result of the establishment of constitutional governments and of the legalization of the methods of conscription and taxation. If a declaration of war or an ultimatum leading to war were subject to a referendum, the vote being taken not too

promptly, and if the estimated cost of the war were collected in taxes in advance, there would not be many wars.

We are still far from having a true political and social democracy. The production of wealth has increased rapidly; but we have not learned to distribute it justly or to use it wisely. The education supplied by our schools is inadequate and inept. We may be confident that a complete democracy will be the strongest force for peace that the world has seen. Even now the great mass of the people, most of them having some education and some property, are the true guarantees against wanton war. A king can no longer summon his nobles and the chiefs gather together their retainers to invade a foreign country. A war which, with its accompanying pestilence and famine, would reduce the population of a country to one half, as in the case of the thirty years' war, is now almost inconceivable. And this we owe to social and political democracy, which in turn we owe to science.

As a result of scientific progress and invention, the law of Malthus has been reversed. The means of subsistence increase more rapidly than the population. The sinister voluntary limitation of childbirth, which may give rise to racial deterioration and actual depopulation, is unnecessary. As population increases under a given condition of culture, the number of men of genius and talent competent to make the labor of each more efficient increases in proportion; as their inventions are of benefit to all, the means of subsistence tend to increase as the square of the population. As the level of education and culture is raised, and as democracy is perfected, so that each is given opportunity to do the work for which he is fit, the wealth and means of subsistence increase still more rapidly. The law of Malthus and the law of diminishing returns, like the law of the degradation of energy, may ultimately prevail, but not in any future with which we are concerned. The population of a civilized country, in which science is cultivated, need not be limited by famine, pestilence or war. Over-population and the need of expansion by conquest are obviated by democracy and science; the cause of war which may be regarded as inevitable and legitimate is thus abolished. In providing adequately for the subsistence of an increasing population, science has made a contribution to peace the magnitude of which can not be easily overstated.

Another great service for peace to be credited to science is the development of commerce, travel and intercommunication. Steam and electricity are handmaids of peace. Trade disputes and the misadventures of missionaries, travelers and immigrants may serve as causes or pretexts of wars, but the balance of commerce, travel and immigration is large on the side of peace. With the existing commerce among the nations, each dependent on every other, a war of any kind does injury to all. A nation at war destroys its own property throughout the world, and all the nations suffer. A neutral nation can no more afford

to countenance a needless war than mobs burning its own cities and killing its own citizens. In New York, London, Berlin and Paris are business houses and representatives of every country in the world. How could any nation wish to destroy or to permit the destruction of these cities?

Ease of travel and quickness of communication hold the large nations and empires together and tend to make the whole world one people. Racial prejudices are sometimes aggravated by close contact; but the acquaintance that comes with business and travel, with knowledge of politics and customs, with daily news cabled about the world, makes foreigners human like ourselves, and killing them becomes murder rather than war. The first cabin and the steerage of every transatlantic liner conduce to acquaintance and friendliness. Ease and cheapness of transportation have led to immigration on a vast scale. Many peoples must include New York when they enumerate their larger cities. Immigrants and their children in this country are numbered by the tens of millions. There are more people with Irish blood in the United States than in Ireland, and the same condition will in the end hold for other nationalities smaller than our own. Men war with their own kindred, but do not readily unite with aliens against them. The admixture of races, which the applications of science have so greatly promoted, surely makes for peace. This is especially the case when close communication is maintained with the mother country, such as is now supplied by the post-office, money order system, newspapers, ease of travel and other conditions of a civilization based on the applications of science.

Science has given us democracy, it has given us ample means of subsistence, it has given us commerce and intercommunication, and these three achievements are the principal factors which have lessened warfare and will eventually lead to its complete abolition. Other contributions of science, though less momentous, are by no means unimportant. Warfare is now in large measure applied science, and this tends towards its decrease. Wars between nations with scientific equipment and savage and barbarous peoples are no longer waged on equal terms and are of short duration. The extermination, despoliation and subjugation of the non-Caucasian races may be the world's great tragedy, and in so far as some of these peoples are able to adopt our science there will be a readjustment which may be written in blood or may be a triumph of common sense and justice. However this may be, the invincibility that science has conferred on the western nations has made them safe from attack and invasion, and while it may on occasion have led to wanton aggression, it has, on the whole, limited warfare. If we call to mind the centuries of invasion and threats of invasion by Northmen, Ottomans and Saracens, we can appreciate the value of the means of defense which science has given to the civilized nations.

The making of warfare an applied science by the western nations and by one eastern nation has tended also to prevent war between nations so equipped. When war is a game of skill rather than of chance, it is likely to be undertaken only after careful consideration of the conditions and consequences. The cost is enormous and must be carefully weighed. The interests of the money lenders are usually on the side of peace and become increasingly so as war continues. If war does occur between two great nations it is likely to be of short duration. It can not drag on through tens of years as formerly. Its horrors are also reduced; non-combatants are not so much concerned, and soldiers suffer less from disease—far more dreadful than violence—owing to the shorter duration of wars and to hygiene, medicine and surgery. It may be hoped that science has accomplished, on the whole, more for defense than for aggression; torpedoes, mines, submarines and aeroplanes are more effective for protection than for attack. The cost of modern armaments is so immense that this in itself will lead to their limitation and to the settlement of difficulties otherwise than by appeal to arms.

There is a psychological aspect of modern scientific warfare, which tends to discredit it. The heroism and the bravery, the excitement of personal contact and the exhibition of personal prowess, the romance and the occasional chivalry, are largely gone. Men cooped up in battleships or displayed like pawns on the field are not much greater heroes to themselves or to others than workers in a mine exposed to nearly equal danger. Officers under constant instructions from the seat of government and telegraphing their orders from a point of safety fall to the level of ordinary men of affairs. Tin soldiers will not forever stir the imagination of children in the nursery. Providence is on the side favored by the money lenders and having the best organized commissariat. War becomes brutal and disgusting; at its best like the business of the hangman, at its worst like infanticide.

War, wine and women as a toy have been so continuously exploited by poetry and art, that a philosopher might well propose to banish such incitements to misconduct from his republic. It is obvious that these things, bred into our blood through long ages when they were useful or at all events natural, stir the emotions and the passions in a way that can not be expected from considerations regarding peace, sobriety and the care of infants. Even religion is primarily racial in its expression. The churches of a nation may on the first day of every month repeat the prayer:

> Up Lord, and help me O my God; for thou smitest all mine enemies on the cheek-bone; thou hast broken the teeth of the ungodly.

Its people may unite in the anthem:

> O Lord our God arise,
> Scatter our enemies,
> And make them fall;

Confound their politics,
Frustrate their knavish tricks,
On thee our hopes we fix,
Oh save us all.

Religion, poetry and art have been of untold value to tribes and peoples; they will surely adjust themselves to the world as it now is and should become. Science needs no reconstruction; it is by its nature universal and gives a common interest and object to all nations. A scientific advance or discovery made in one place is equally true and equally important everywhere. When a state appropriates money for research or when a university or scientific foundation is endowed by private gift a contribution is made to the welfare and to the peace of the whole world. Smithson, an Englishman, might well establish the institution that bears his name in the United States: it is for the "increase and diffusion of knowledge among men."

The methods of science and the spirit of science are adverse to the jealousies, resentments and passions which lead to war. Dependence on hypotheses and induction tends to careful weighing of facts and delay before coming to conclusions. The quantitative method, the application of mathematics and probability, enables us to measure our knowledge and our ignorance. The genetic method discredits revolutions and catastrophes; it gives us faith in the slow processes of evolution. The writer, a psychologist by profession, knows very well that a scientific man may be correct and cautious in his researches, but unwise and rash in other relations of life. None the less it is true that the spread of scientific education and of scientific investigation is slowly leading to objective points of view and moral conduct in daily life. The scientific spirit is a pervasive and permanent force making for the world's peace.

Science not only gives us peace, but also the means to make worthy use of peace. An industrial civilization in which each has as many comforts and is spared as much misery as may be strikes our inherited instincts as a tame and tiresome Walhalla. But science gives us an object; it can even satisfy the inborn spirit for excitement and adventure. The frontiers in the wilderness disappear as civilization encircles the earth; but the frontiers of science will always become larger and more remote as they are further extended. War between nations may become inconceivable; but however numerous may be the battles waged and won by science, there will always be unconquered worlds beyond. The hundred thousand physicians of our country, its fifty thousand engineers, its ten thousand men of science engaged in research, form an army more inspiring to the imagination than soldiers idling in barracks or confined in the venereal wards of hospitals. The dealing with germs of disease, with poisons, explosives and radiations, is not less heroic than the risking of life on the battlefield.

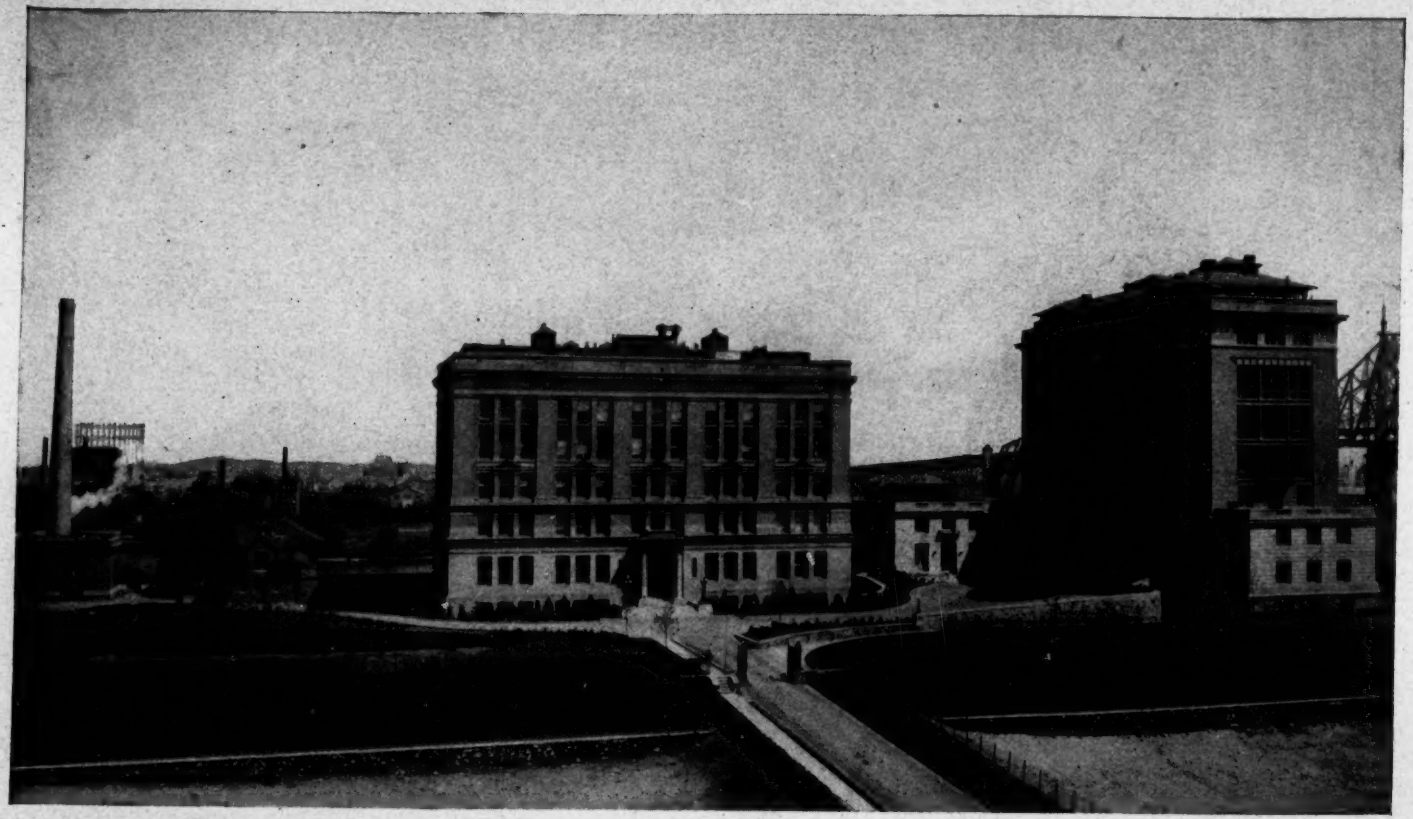
A scientific man has relations with his fellow workers in the same field throughout the world. In some narrow specialties he may know that his paper will be read by not more than twenty people who may be citizens of ten different nations. He belongs to a social group or fraternity which is independent of language or nationality. A scientific subject, whether large or small, is built up by contributions accruing from many nations. The symbols of mathematics, physical constants, the names of species and genera, in large measure the terminology of all the sciences, form an international language. It is easy to read scientific literature in English, German and French; practically all those engaged in research work can do so. Communication by way of the mails and the printing press and interest in a common subject lead to personal contact and acquaintance, which have been especially forwarded by the university. When the present writer was assistant in the psychological laboratory of Professor Wundt at Leipzig twenty-five years ago, more than half the research students came from beyond the borders of Germany. They now hold professorships in universities in many different countries. In the classes of the writer at Columbia University last year, there were represented Great Britain, Germany, France, Italy, Russia, Denmark, Bulgaria, South America and Japan. Interchange of professors as well as of students has become a feature of academic life. Scientific men from foreign nations are continually visiting our institutions and lecturing at our universities. Each is an ambassador of peace and good will.

The common interests of scientific men have led to their organization in international conferences and congresses. These bodies are more numerous than is commonly known. The Central Office of International Institutions at Brussels, which aims to become a clearing-house in its field, enumerates as many as 280, most of which are concerned with science in its wider aspects. Dr. P. J. Eijkman, of the Hague, in his *L'Internationalisme scientifique* gives a list of 614 societies and organizations in the main scientific and international in character. International congresses devoted to each of the sciences and to the applications of science in the various branches of engineering and medicine meet periodically, each time in a different country. Experience shows that the organization of an international congress is not always conducive to domestic peace, but such difficulties perhaps dispose us to appreciate all the more the good qualities of foreigners. Certainly these congresses, bringing together men from different nations and giving them opportunity to cooperate for their common ends, have a real and increasing influence toward international good-will.

International congresses, conventions and conferences often lead to permanent plans and institutions for international cooperation. Some of these, such as the Hague conferences, are directly concerned with preventing wars or ameliorating their conduct. Others, such as the

postal and copyright conventions or the International Bureau of the American Republics, are semi-scientific in character. Still others are concerned with the applications of science or with scientific research. Examples of these are the International Bureau of Weights and Measures at Paris, the International Geodetic Bureau at Strasburg, the International Institute of Agriculture at Rome, the International Catalogue of Scientific Literature at London, the Nobel Institutes at Stockholm and the Naples Zoological Station. There are international committees on electrical units, on mapping the earth and the skies, on deep-sea exploration and the like. We have attained a common calendar and a meridian of Greenwich with standard time. The metric system is becoming universal, and there is no reason why the gram of pure gold should not be adopted as a monetary standard. The exact definition of boundaries and other applications of science to international questions do away with the misunderstandings that may lead to war.

International cooperation in science and scholarship and in their applications has reached such dimensions that it may be that the time has come when a truly international university might be established to advantage. If each nation would reduce its armaments to the extent of one per cent. and devote the money to the establishment and support of an international university, this step would in itself reduce the risks of war by more than one per cent. Such an institution could consequently be established without cost, and would be of vast intellectual, social and economic benefit to the world. It could be placed in Holland, Belgium or Switzerland, or perhaps still better in a territory made international for the purpose, such as one of the channel islands or Monte Carlo, wherever conditions of access, climate and environment would be most favorable. The conduct of such a territory and institution would give profitable practise in international cooperation. The high traditions of the university would be made tributary to international good-will and would themselves be further developed for the benefit of universities everywhere. Libraries and museums of international scope for the preservation of standards, type specimens, archives, etc., might to advantage be gathered together. Research institutions could be established by states or by private endowment; for the scientific work which is not primarily of benefit to a single individual or even to a single nation, can most properly be supported by all. By the establishment of an international university the nations would in part repay, or at least acknowledge, the debt which they owe to science for its services on behalf of the peace and welfare of the world.



THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH.

THE PROGRESS OF SCIENCE

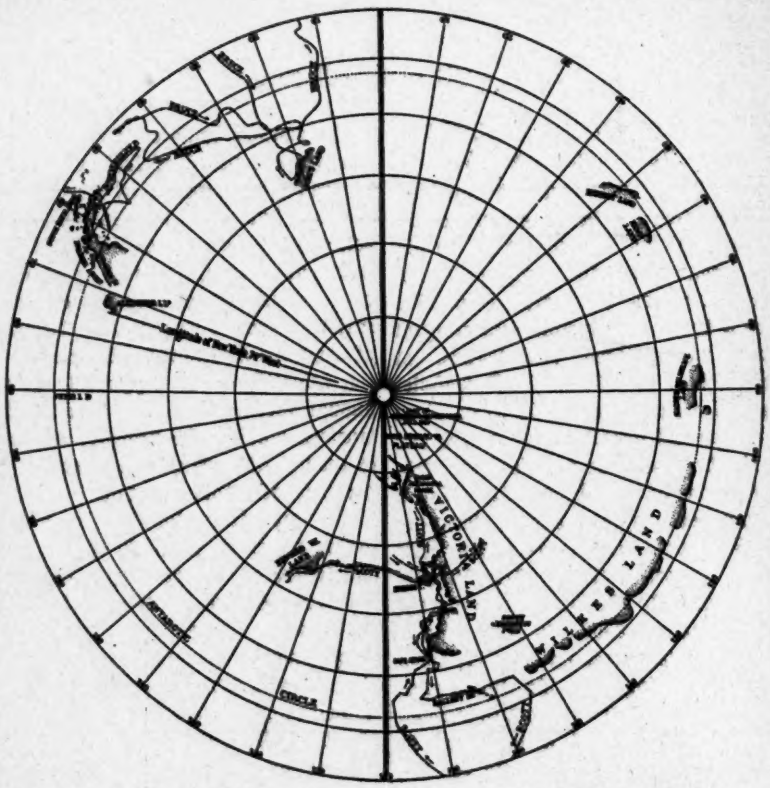
THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH

THE Rockefeller Institute for Medical Research has issued an interesting brochure giving an account of its history, organization and equipment. The institution was incorporated in 1901 with a board of directors consisting of seven distinguished pathologists, at which time Mr. John D. Rockefeller pledged a sum of $200,000 to be given in ten annual installments. At the end of the first year, he promised an additional sum of a million dollars for a building and support, and in that year the Schermerhorn estate on the East River, between 64th and 67th Streets, was purchased. Buildings were erected costing about $300,000, the formal opening taking place on May 11, 1906. In the following year Mr. Rockefeller gave an endowment of over two million, six hundred thousand dollars, and in 1908 arrangements were made for the construction of a hospital which cost $900,000. Other gifts followed from Mr. Rockefeller and the endowment fund now amounts to over $7,000,000.

At first the funds of the institute were used only for grants to investigators, but in 1902 Dr. Simon Flexner, then professor in the Johns Hopkins University, was elected director, and in 1904 research was begun by the institute. The original staff included, in addition to Dr. Flexner, Drs. S. J. Meltzer, E. L. Opie, H. Noguchi, P. A. Levene and J. Auer. Dr. Opie has since removed to St. Louis, and the scientific staff has been strengthened by the addition of Drs. Jacques Loeb, Alexis Carrel, Rufus Cole and other distinguished investigators. The original directors of the institute agreed in 1908 to become themselves a board of scientific directors, and to transfer to a board of trustees the management of the property. Both boards appear to form the corporation, their relations being somewhat unusual. The present board of trustees was appointed by the board of scientific directors, but they will in future be selected by the trustees. The arrangement, however, gives much more influence to scientific men than the organization of our universities, as the board of scientific directors retains control of the scientific work supported by the annual income, and one third of the trustees holding the property are men of science who are also members of the board of scientific directors.

The laboratory building is a fireproof structure of light gray brick and limestone, commanding a beautiful view of the East River and the country beyond. There are laboratories of pathology, bacteriology, chemistry, physiology, pharmacology, experimental medicine and experimental surgery, each of which is under the charge of a member or associate of the institute with a staff of assistants. The hospital includes a main building and an isolation pavilion for contagious diseases. Its capacity is about seventy beds and its work is confined to selected cases bearing on a limited number of diseases, those first selected having been acute lobar pneumonia, infantile paralysis, syphilis and certain types of cardiac disease. No charge is made for persons treated in the hospital, and all discoveries and inventions made by those working in the institution become its property to be placed freely at the service of the public.

The institution publishes *The Journal of Experimental Medicine*, a series of monographs and a series of studies. In its first ten years the institute has produced a large number of researches of great importance both for pure science and for applied medicine. Some of these have been described in this journal by the director, Dr. Flexner,



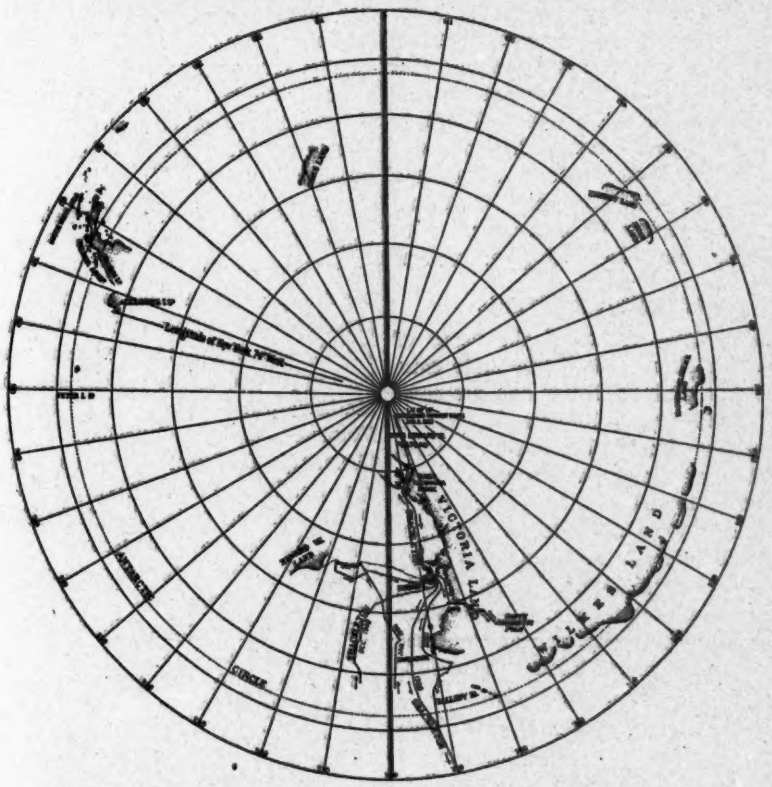
ROUTES FOLLOWED BY OTTO NORDENSKJÖLD, 1902-1903; R. F. SCOTT, 1902-1904; W. S. BRUCE, 1903-1904.

and we hope that it may be possible to publish here other articles containing accounts of work that in importance is not exceeded by that being accomplished in any science in any part of the world.

EXPLORATION AND ADVENTURE IN THE ANTARCTIC

THE attainment of the South Pole is of dramatic and sporting interest to every one, and such expeditions are likely to yield scientific results of value. There is a dramatic appeal in the fact that the most remote and inaccessible ends of the earth have at least been brought within reach, in the north by Commander Peary and now in the south by Captain Amundsen. These quests have to a certain extent been international games of skill and endurance. In the present instance this aspect has been emphasized by the fact that Captain Amundsen secretly departed from his planned expedition to the Arctic to engage in the race with Captain Scott. We may hope that both reached the goal. It is not a matter of consequence whether it was first attained by a descendant of the vikings or by the people that sent Cook, Weddell, Ross, Scott and Shackleton to press each further than his predecessor to the south. The Monroe doctrine presumably does not include in its scope the Antarctic continent; but it seems unfortunate that we have done less than our share to explore the land immediately south of us.

It probably does not violate the copyright so carefully guarded by the New York *Times* on behalf of Captain



ROUTE FOLLOWED BY E. H. SHACKLETON, 1908-1909.

Amundsen to state that the explorer reached the pole on December 14, and remained there for three days. The sun was bright, and observations were carefully made with the sextant and artificial horizon. The great snow plane elevated more than 10,000 feet above the sea was named King Haakon Plateau, though it may be that priority should be given to the name of King Edward VII. Land, as the plateau extends to the point within ninety-seven miles of the pole reached by Lieutenant Shackleton on January 9, 1909. The *Fram*, made famous by Dr. Nansen's expeditions, reached the Bay of Wales, south of New Zealand at a latitude of 78 degrees and 40 minutes on January 14 of last year. There it was seen by the *Terra Nova* of Captain Scott's expedition, and news was thus first given to the world of Captain Amundsen's plans.

The trip to the pole was begun on October 20 and proceeded without noticeable event at the rate of twenty miles a day. The general course can be traced on the maps, showing the course of previous expeditions, reproduced here by courtesy of the American Museum of Natural History. The cold and blizzards were a serious hindrance, but not so bad as traveling over the floating ice floes in the north without the possibility of establishing depots for food and being assured of a return by the same route. The great ice plane without a trace of life appeals to the imagination, but traversing it has probably not added considerably to our scientific knowledge, and there does not seem to be much likelihood of economic

gains. The coal discovered by Lieutenant Shackleton is only of scientific interest in showing the changes that have taken place in the climate.

Captain Amundsen, who had already won fame by traversing the Northwest Passage, probably regards his expedition to the pole as only an episode, and will proceed with his plan to drift with the ice across the north polar regions.

SCIENTIFIC ITEMS

WE regret to record the death of Dr. John Bernhardt Smith, state entomologist of New Jersey and professor of entomology at Rutgers College; of Professor Mason Blanchard Thomas, professor of botany at Wabash College; of Dr. Charles Robert Sanger, professor of chemistry and director of the chemical laboratory at Harvard University; of Dr. Henry Taylor Bovey, F.R.S., formerly professor of civil engineering in McGill University, and of Professor Osborne Reynolds, F.R.S., the distinguished engineer and physicist.

MR. SAMUEL HENSHAW has been appointed director of the Museum of Comparative Zoology of Harvard University.—Professor Charles Sedgwick Minot has been selected by the German government as Harvard exchange professor at the University of Berlin for 1912–13. Dr. Rudolf Eucken, professor of philosophy at Jena, has been appointed exchange professor at Harvard University.—Dr. Talcott Williams, associate editor of the Philadelphia *Press*, has been appointed director of the School of Journalism of Columbia University, founded by Mr. Pullitzer. Professor John W. Cunliffe, now head of the department of English of the University of Wisconsin, is the associate director of the school.

FOR the meeting of the British Association for the Advancement of Science, which is to be held this year at Dundee, beginning on September 4, under the presidency of Professor E. A. Schäfer, F.R.S., the following presidents have been appointed to the various sections: Mathematical and Physical Science, Professor H. L. Callendar, F.R.S.; Chemistry, Professor A. Senier; Geology, Dr. B. N. Peach, F.R.S.; Zoology, Dr. P. Chalmers Mitchell, F.R.S.; Geography, Sir Charles M. Watson, K.C.M.G., C.B., R.E.; Economic Science and Statistics, Sir Henry H. Cunnyghame, K.C.B.; Engineering, Professor A. Barr; Anthropology, Professor G. Elliot Smith, F.R.S.; Physiology, Mr. Leonard Hill, F.R.S.; Botany, Professor F. Keeble; Educational Science, Professor J. Adams; Agriculture, Mr. T. H. Middleton.

THE treasurer of Columbia University has reported to the trustees that he had received about $1,550,000 from the executors of the estate of the late George Crocker. Accordingly, the work of cancer research, for which Mr. Crocker gave this sum as an endowment, will begin at once.